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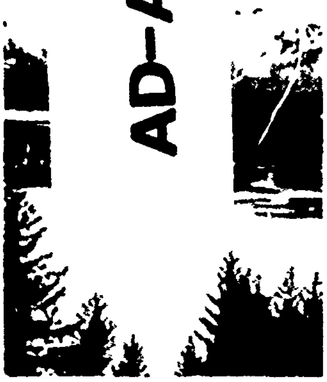

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TECHNICAL REPORT EL-89-17

HABITAT UTILIZATION BY JUVENILE PINK AND CHUM SALMON IN UPPER RESURRECTION BAY, ALASKA

by

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Patterns of habitat utilization by juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon were studied in Resurrection Bay at a proposed small-boat harbor construction site near Seward, AK. Relative distribution and abundance of salmon fry and their predators were determined by beach seining during the outmigration period at six stations in upper Resurrection Bay; estuarine residence time of salmon fry was determined by otolith analysis; and predation on salmon fry and food habits of salmon fry were qualitatively assessed. The outmigration period lasted from mid-April through mid-May and peaked in the first week of May during both years of the study. Catches of salmon fry and their predators were highest at seine stations located in the proposed harbor area. The most consistently occurring food items in stomachs of both pink and chum salmon were epibenthic harpacticoid copepods and planktonic calanoid copepods. Fry predators included Dolly Varden (*Salvelinus malma*), sculpin (*Leptocottus* spp. and *Myoxocephalus* spp.), and juvenile coho salmon

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19. ABSTRACT (Continued).

(*O. kisutch*). Otoliths of juvenile pink and chum salmon exhibited daily growth increments, which were deposited after saltwater entry. Chum salmon (maximum age = 51 estuarine days, mean age = 11.8 days) remained in the study area much longer than pink salmon (maximum age = 18 estuarine days, mean age = 0.7 days).

PREFACE

This report was sponsored by Headquarters, US Army Corps of Engineers (HQUSACE), as part of the Environmental Impact Research Program (EIRP) Work Unit 31627, entitled "Effects of Channels and Jetties on Fish and Shellfish Migration." The Technical Monitors for the study were Dr. John Bushman, Mr. David P. Buelow, and Mr. David Mathis of HQUSACE.

This report was prepared by Ms. Mary W. Faurot, Mr. Steve W. Landino, and Mr. Reg R. Reisenbichler, US Fish and Wildlife Service (USFWS); and Dr. Douglas G. Clarke, US Army Engineer Waterways Experiment Station (WES), under a cooperative agreement between WES and the USFWS.

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Dr. Clarke was the WES Technical Advisor for the agreement under the general supervision of Mr. Edward J. Pullen, Chief, Coastal Ecology Group; Dr. Conrad J. Kirby, Chief, Environmental Resources Division; and Dr. John Harrison, Chief, Environmental Laboratory, WES. Dr. Roger T. Saucier, WES, was the Program Manager of EIRP. This report was edited by Ms. Lee T. Byrne of the Information Technology Laboratory, WES.

COL Larry B. Fulton, EN, was Commander and Director of WES. Dr. Robert W. Whalin was Technical Director.

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CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
degrees (angle)	0.01745329	radians
knots (international)	0.5144444	metres per second

HABITAT UTILIZATION BY JUVENILE PINK AND CHUM SALMON IN UPPER RESURRECTION BAY, ALASKA

PART I: INTRODUCTION

1. Patterns of habitat utilization by juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon were studied in Resurrection Bay at a proposed small-boat harbor construction site near Seward, AK.* These salmon populations had not been surveyed before and may be extremely sensitive to environmental changes caused by construction of the breakwater. This report presents the results of the 2-year preconstruction study that can be applied to studies of similar coastal engineering projects in waters occupied by anadromous fishes and that will serve as a baseline to be measured against once construction has been completed.

2. The proposed harbor location lies at the mouth of the Resurrection River (Figure 1), which, along with its tributaries, provides major spawning habitat for several species of anadromous salmon important to commercial and sport fisheries. Pink and chum salmon stocks from this and other Resurrection Bay systems are harvested in Resurrection Bay as part of the Lower Cook Inlet (Eastern District) commercial fishery, which is managed by the Alaska Department of Fish and Game. Because of the 2- ar life cycle of pink salmon, adults return to spawning streams in pr able and highly segregated even-numbered-year and odd-numbered-year runs. In Resurrection Bay, even-numbered-year runs are dominant, and in strong years, over 100,000 pink salmon and over 10,000 chum salmon are commercially harvested (Alaska Department of Fish and Game 1987). Annual spawning runs (escapement) in Resurrection River tributaries average over 30,000 pink salmon (Table 1). Coho salmon (*Oncorhynchus kisutch*) are not fished commercially in this area, but the coho salmon sport fishery is the second largest in Alaska, with an annual harvest of over 17,000 fish (Vincent-Lang, Bernard, and McBride 1988). The coho salmon management program in Resurrection Bay involves supplemental plantings of fry

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* US Army Engineer District (USAED) Alaska. 1982. "Detailed Project Report and Final Environmental Impact Statement: Proposed Small Boat Harbor Navigational Improvements, Seward, Alaska, 1982," Unpublished Report, Alaska District, Anchorage, AK.

and fingerlings, monitoring smolt and adult migrations, and evaluating the sport fishery.

3. This study focused on juvenile pink and chum salmon, considered the primary juvenile salmonids of concern in shallow nearshore estuarine areas due to their small size during outmigration (in contrast to other local salmonids) (Hiss and Boomer 1986). Juvenile pink and chum salmon (hereinafter referred to as salmon fry) emerge from the gravel in spawning streams after absorbing most of their yolk sacs and within a few days migrate directly to the sea. The timing of emergence is determined by stream temperatures during incubation (Sheridan 1962) and, in Alaska, has been correlated with increased or peak water flows following ice breakup (Buklis and Barton 1984). Fry in Alaska generally begin emerging during April or May and continue over a 1-month span (Sheridan 1962, Morrow 1980). Outmigrating pink salmon range from 28 to 32 mm in length (Sheridan 1962, Rogers and Burgner 1967), and chum salmon from 35 to 40 mm (Kirkwood 1962). Emergence and outmigration usually occur at night, and in short coastal streams, fry reach the marine environment by dawn (Neave 1955, Bailey 1969). Little or no feeding occurs during short migrations, and yolk reserves may not be completely depleted until marine residence is established (Rogers and Burgner 1967, Morrow 1980).

4. Extensive literature exists regarding the estuarine and marine ecology and behavior of juvenile salmon in waters off the coasts of Washington and British Columbia; less is available representing Alaskan systems. In all systems, however, estuarine residence is extremely important to pink and chum salmon fry as the result of a number of life history requirements. Fry use shallow inshore waters (typically estuarine areas) as nurseries and require a critical period spent in these low-salinity habitats to undergo growth and make osmoregulatory adjustments prior to migration into offshore marine waters. Residence time (total time that juvenile salmon occur in nearshore estuarine habitats) is determined by size at saltwater entry, availability of preferred prey, river discharge, and estuarine topography (Simenstad, Fresh, and Salo 1982). Pink salmon remain in shallow, nearshore zones for periods of 2 days to 1 month, and when a size of 40 to 60 mm is attained, begin gradual, irregular movement to offshore habitats (Thorsteinson 1962, McInerney 1964, Neave 1966, Bailey 1969). Chum salmon residence times are longer, ranging from 1 week to 2 months before offshore movement begins (Mason 1974; Bax and Whitmus 1981; VTN Oregon, Inc. 1981).

5. During residence in estuarine waters, fry form schools near shore during daylight hours and disperse at night (Hoar 1956, Neave 1966). Juvenile pink salmon generally remain near the surface in slow water areas (Bailey 1969), whereas chum salmon are more benthic, preferring mud or sand bottoms with eelgrass for cover (Meyer 1979). Mortality of fry during early marine life is high (Parker 1968, 1971), primarily due to predation. Known fry predators include birds, marine mammals, large marine invertebrates, and fishes such as Dolly Varden (*Salvelinus malma*), juvenile coho salmon, herring (*Clupea harengus*), Pacific tomcod (*Microgadus proximus*), and sculpins (*Myoxocephalus* spp. and *Leptocottus* spp.).

6. The first few months that fry spend in the sea are typically a time of rapid growth. Adequate food resources in nursery areas are critical to fry survival during this period (LeBrasseur and Parker 1964, Healey 1979). Chum salmon fry rely primarily on epibenthic harpacticoid copepods and amphipods, whereas pink salmon are dependent on more pelagic zooplankters (Kaczynski et al. 1973; Bailey, Wing, and Mattson 1975; Cooney et al. 1978; Healey 1979; Simenstad 1980; Godin 1981).

7. The location of the proposed harbor lies immediately adjacent to the path of outmigrating salmon fry from the Resurrection River (Figure 2) and may encompass a fry nursery area. Project design involves a rubblemound breakwater that will extend approximately 275 m into the bay, run parallel to shore for about 760 m, and will include a midtide breach in the northern breakwater as a passageway to facilitate movement of fry through the harbor. The inner portion of the harbor will be dredged to a uniform depth of 5.5 m.* Harbor construction would have the following physical effects: (a) approximately one-third of the intertidal area of the Resurrection River would be altered, (b) several braids of the delta would be rechanneled, (c) 118 acres** of tidal flats would be eliminated by dredging and construction, and (d) the mouth of the river would eventually shift to the west. Environmental concerns include the following: (a) nursery or rearing habitat may be modified, (b) salmon fry may be forced to move seaward without sufficient time spent in nursery habitats, (c) salmon fry may be impeded in their normal movement down the

* USAED, Alaska, op. cit.
** A table of factors for converting non-SI units of measurement to SI (metric) units is found on page 3.

shoreline of the bay, (d) salmon fry may be forced to spend a disproportionate amount of time in deeper waters where they may be exposed to increased predation pressure and suboptimal food resources, (e) fry may become concentrated within or around the breakwaters and thereby be preyed upon by fishes attracted to the structures, and (f) salmon fry may suffer the effects of reduced water quality resulting from increased siltation, temperatures, and discharge of boat wastes.

8. In view of these concerns, this preconstruction monitoring study was developed so that it could be replicated in postconstruction studies. The objectives were as follows:

- a. To establish the spatial and temporal distribution and relative abundance patterns of juvenile pink and chum salmon in inshore and offshore zones of the upper reaches of Resurrection Bay.
- b. To assess qualitatively the dependence of juvenile pink and chum salmon on planktonic versus epibenthic food resources as a means to estimate the value of the intertidal nursery habitat.
- c. To evaluate predation on juvenile pink and chum salmon in intertidal habitats in the proposed harbor area.
- d. To estimate outmigration timing.
- e. To estimate estuarine residence time for juvenile pink and chum salmon at the project site.
- f. To establish the patterns of relevant physical and water quality parameters in the upper reaches of Resurrection Bay.

PART II: STUDY AREA

9. Resurrection Bay is a fjord estuary located on the Kenai Peninsula of south-central Alaska (Figure 1). The Resurrection River empties into the northeastern terminus of the bay through a large deltaic wetland area. Otherwise, the surrounding bay has steep slopes that drop to depths of 100 to 300 m. Glacial icefields overlook the bay, and strong winds and heavy precipitation are characteristic of the area. Winds are predominately from the south between April and September and northerly during the rest of the year.

10. The city of Seward, a community of approximately 2,500 people, is located on the northwestern shore of Resurrection Bay. Major industries are commercial fishing, tourism, and the Alaska Railroad. In addition, Seward is the site of an Alaska Marine Highway System ferry terminal, a vocational training school, and a field experiment station for the University of Alaska's Institute of Marine Science. Seward is served by the Alaska Marine Highway System, commercial air service, a State highway, and the Alaska Railroad.

11. The shoreline of Resurrection Bay is subject to two diurnal tides of relatively great range, with an extreme range of about 6 m, a mean range of 2.5 m, and a mean diurnal range of 3.2 m. Marine waters of the outer bay are relatively clear with low concentrations of suspended sediments except during glacial melt or storm wave activity. The Resurrection River is a glacial stream, has formed sediment deposits in the upper bay, and contributes a considerable silt load to the entire bay during glacial melt. Peak discharge occurs mainly between July and September and varies from approximately 75 to 500 m^3/sec, the average being about 110 m^3/sec. During the winter, fresh water input drops to below 50 m^3/sec and may be as low as 10 m^3/sec between January and March (US Geological Survey, unpublished data). Generally, the less dense fresh water overlays the denser marine water and flows seaward out of the bay. The seaward flow of fresh water at the surface entrains dense marine water from below; this process results in a longitudinal salinity gradient and an up-estuary flow beneath the surface outflow. This generalized flow pattern describes a unique estuarine circulation characteristic of relatively shallow depths within fjords such as Resurrection Bay (Heggie, Boisseau, and Burrell 1977).

12. The study area for this investigation encompassed the Resurrection River below Salmon Creek, lower Salmon Creek, and the upper intertidal reaches

of Resurrection Bay southward to Fourth of July Creek and Lowell Point (Figure 2). A freshwater sampling station was established in Salmon Creek, two estuarine stations were established within or closely adjacent to the proposed harbor site, and four additional stations were established in surrounding reaches of the bay. Photographs depicting general aspects of the proposed harbor site and each estuarine station are presented in Figure 3. The upper intertidal areas of the three easternmost stations (designated Noname, Cliff, and Houseboat) consist of loose graywacke slate from 2 to 50 cm in size. The lower intertidal areas of these stations and the total intertidal area of the two northernmost stations (designated North and Greenhouse) consist of approximately 66-percent sand and 34-percent silt. Both upper and lower intertidal areas at the southernmost station (designated Lowell Point) consist of cobbles. The bottom at the four northernmost stations is relatively flat and shallow, with increasing slope with distance to the southwest, dropping off abruptly around 1 km from shore. The bottom at the two southernmost stations drops abruptly beyond the intertidal area (Figure 2). Common intertidal aquatic vegetation includes eelgrass (*Zostera* spp.), rockweed (*Fucus distichus*), sea lettuce (*Ulva* spp.), and kelp (*Laminaria* spp.).

PART III: METHODS

13. Fieldwork was conducted for 2 years during the outmigration period of Alaskan pink and chum salmon fry. In 1986, sampling began during the first week of April and was completed by the third week of May except for one sampling in mid-June. In 1987, sampling commenced during the third week in April and was completed during the last week in June.

Inshore Species Composition, Distribution, and Relative Abundance

14. To assess inshore species composition, distribution, and relative abundance of juvenile salmon and their predators, beach seining was conducted at six stations across the upper shoreline of Resurrection Bay (Figures 2 and 3). A beach seine 27.4 by 1.8 m constructed of 4.7-mm square ace mesh with a 3.2-mm square ace mesh bag was used. Three replicate hauls were conducted at each station at both high and low tide each week throughout the sampling period during each year. Because of dewatering and subsequent seining inefficiency at low tide, no low tide seine sampling was conducted at Noname in 1987. Records of the numbers and species of all fishes caught were maintained. Random subsamples of juvenile pink and chum salmon from every station and fry predators from harbor stations were preserved in 70-percent ethanol for length, age (fry only), and stomach content analyses.

Offshore Juvenile Salmon Distribution

15. To assess offshore juvenile salmon distribution in upper Resurrection Bay, tow netting was undertaken weekly during May 1986 and during the week of 8 June 1987. The tow net measured 2.7 by 2.7 m across the mouth, was 8.2 m in length, and was constructed of mesh sizes varying from 3.2 to 38 mm. A 20-min surface tow was made weekly along each of 5 transects in 1986 and once along each of 10 transects in 1987 (midbay transects were added in 1987) (Figure 2).

Juvenile Salmon Food Habits

16. To establish the degree of juvenile salmon dependence on planktonic versus epibenthic food resources, six pink and six chum salmon juveniles from each station (three from each tide stage) from 19 May through 22 May 1986 (the most productive beach seining week in terms of juvenile salmon catches) were randomly selected, and their stomach contents were identified. The number of stomach samples in which one or more of a given food item was found was recorded.

17. The frequency of occurrence of epibenthic and planktonic food resources in fry stomachs was calculated by taking the number of stomachs that contained one or more of a given food item and expressing it as a percentage of the total number of nonempty stomachs (Windell and Bowen 1978), thereby estimating the proportion of the population that fed on that particular item. The same method was used to determine the frequency of occurrence of salmon fry in predator stomachs.

Predation on Juvenile Salmon

18. To evaluate the level of predation on juvenile salmon in intertidal habitats in the proposed harbor area, fry predators from the two harbor site stations (Noname and Cliff) were randomly subsampled from beach seine catches and preserved for stomach contents analysis. Fry predators were identified in 1986 by opportunistically subsampling all potential predator species. Fry predation was systemically analyzed in 1987 by subsampling up to 10 fish per predator species (coho salmon, Dolly Varden, great sculpin (*Myoxocephalus polyacanthocephalus*), and staghorn sculpin (*Leptocottus armatus*) from seine hauls from each harbor site station for each tide level each week. Some of the predators were not likely to have ingested fry because of their small size and were eliminated from further stomach content analysis. Predator fork length to the nearest millimetre and numbers of pink and chum salmon fry per stomach were recorded.

Outmigration Timing

19. Several methods of sampling were employed in fresh water to determine approximate outmigration timing and to collect reference samples for age determination. Sampling focused on Salmon Creek, a major tributary to the lower Resurrection River with known salmon spawning and relatively easy road access. A fyke trap, 0.91 m in diameter, 2.7 m long, with 2.7-m wings and constructed of 4.7-mm square Delta 15.9-kg netting, was deployed 1 to 4 nights per week from 2 April through 5 May 1986. The sampling station was located approximately 150 m downstream of the Nash Road bridge (Figure 2). The net was typically placed in midchannel facing upstream and was cleaned and checked every 6 to 12 hr. Collected juveniles were identified, subsampled, and measured for fork length (millimetres).

20. Sampling was also conducted in Salmon Creek using a 2.7-m-long smolt net with a 0.46-m-diam mouth, constructed of 2.3-mm knotless nylon mesh, and with a large baffled cod end for low-stress capture of live fish. Sampling occurred on 1 to 3 nights per week from 9 April through 21 May 1986 and from 20 April through 3 June 1987. The net was suspended from the Nash Road Bridge into the area of greatest apparent flow in Salmon Creek and was checked every 2 to 12 hr. Collected juveniles were identified, subsampled, measured for fork length (millimetres), and preserved in 70-percent ethanol for otolith analysis.

21. Other tributaries of the Resurrection River and Bay were sporadically sampled in 1986 to determine outmigration timing and contribution to the Resurrection Bay juvenile salmon population. Minnow traps were used to sample Fourth of July, Spring, Noname, Bear, and Salmon Creeks and the mainstem Resurrection River (Figure 2). Sampling was conducted intermittently at these locations from 10 April through 21 May 1986. The traps were baited with salmon eggs and placed in the streams overnight. All collected fish were identified and recorded, and collected pink and chum salmon juveniles were subsampled and preserved in 70-percent ethanol.

Determination of Estuarine Residence Time

Pond evaluation

22. A study to identify otolith increment periodicity for kno   a fry was conducted in an experimental saltwater pond on the grounds of t . University of Alaska Institute of Marine Science facility. The rubber-lined pond has a capacity of 1,000 m^3. Nutrient-rich water from a depth of 73 m is pumped into the pond. The exchange rate with Resurrection Bay is 5 percent per day.

23. Several preliminary evaluations of conditions in the experimental pond were made prior to the introduction and rearing of salmon fry. To qualitatively determine the food supply present in the pond, three oblique plankton tows (bottom depth, 4.3 m; diameter of net, 18 cm; mesh size, 0.2 mm) were made from the shoreline once during the last week of April and once during the first week of May 1987. During the last week of April, 20 pink and 5 chum salmon fry (captured in Salmon Creek that morning and believed to have emerged from the gravel that day) were introduced into the pond. The fry remained in the pond (within a 1- by 1-m, 5-mm-mesh netpen) for 1 week; then they were removed, and their general condition was assessed.

Rearing of known-age fry

24. During the first week of May 1987, 439 pink and 4 chum salmon fry from the Salmon Creek smolt-net samples were transferred to the experimental pond in an aerated cooler filled with stream water. Only healthy fry were introduced into the pond. Fry were sampled at approximately weekly intervals with a 7.5- by 2-m, 0.5-cm-mesh seine from mid-May through late June. Fish were preserved in 70-percent ethanol for the subsequent extraction of sagittal otoliths.

Otolith extraction and preparation

25. Each fish was positioned under a dissecting microscope, and both of the otoliths were removed through a single dorso-ventral incision through the dorsal surface of the head, perpendicular to the longitudinal axis. Membranes adhering to the otoliths were removed in a water bath, and the clean otoliths were mounted sulcus sides down on glass slides with a heat-sensitive plastic resin. Otoliths were ground to the maximum diameter with a grinding jig (Neilson and Geen 1982) using 1.0-μ alumina polishing compound.

Otolith reading and
daily growth increments

26. When available, otoliths from 10 fish of each species (pink and chum salmon) from each sampling week (1987) from each seine station were analyzed. Analysis was performed on additional fish collected during the first week of May (the week exhibiting the highest catches of salmon fry). Otoliths were also analyzed from pink salmon collected at weekly intervals from the experimental pond (10 fish sampled from each of the 7 weeks of pond residence). In total, otoliths were examined from 301 unknown-age fry (203 chum and 98 pink salmon) and from 71 known-age fry (1 chum salmon and 70 pink salmon).

27. The numbers of daily growth rings or increments were counted on each otolith to give estuarine age in days. An increment was defined as a thin, dark band plus an associated wider, light band when viewed under a microscope with transmitted light (Campana and Neilson 1985). In addition to the otolith readings, fork length was recorded for each fish.

28. Prepared otoliths were viewed with transmitted light under a compound microscope at magnifications of X250, X400 or X1,000. Counts of increments were made along a radius of the dorsal lobe approximately 135 deg from the rostral portion of the longitudinal axis of the otolith (Figure 4), unless increments along this axis were obscured. A radius between 90 and 180 deg from the longitudinal axis was used when the 135-deg radius was judged unacceptable.

Physical and Water Quality Parameters

29. Spatial, seasonal, and tidal patterns of physical and water quality parameters were identified by measuring current speed, current direction, optical turbidity, water temperature, dissolved oxygen, conductivity, and pH at each beach seining station (Figure 2). Sampling was conducted at inshore and offshore sites during low and high tide. Inshore sites were located as closely as possible to the shoreline (with a minimum of 1-m bottom depth); offshore sites were located offshore the beach seining sites at bottom depths of 4.6 to 6.1 m. Physical data were collected at bottom, midcolumn, and surface levels at offshore sites and from bottom and surface levels at inshore sites. One complete set of physical data was collected between 18 April and

7 May 1986. Water temperature, dissolved oxygen, conductivity, and pH were measured weekly at harbor stations and intermittently at nonharbor stations between 20 April and 26 June 1987.

30. Water temperature, dissolved oxygen, conductivity, and pH were measured with a Hydrolab Surveyor II.* Transmitted light and scattered light as functions of optical turbidity were measured with a Montedoro-Whitney TMU-3 Transmissometer/nephelometer. Current speed and direction were measured with an Endeco Type 110 Remote Reading current meter.

Analysis

31. Percent composition was used as an index of relative abundance of fry and fry predators for comparison between beach seining stations. Catch per unit effort (unit effort = seine haul) was also used to compare the spatial and temporal distribution and abundance of salmon fry, fry predators, and other species caught during beach seining. Catch per unit effort was calculated by dividing the total catch for each species by the number of seine hauls on each date. Comparisons were made for catches from pooled or partitioned stations, station types (harbor or nonharbor, east or west, north or south), dates, and tide stages, using t-test procedures to test the null hypothesis that no difference existed in catches of pooled or partitioned fry and fry predators between high and low tide samples, station types, or sample years. An observed significance level of $P \leq 0.05$ was used to reject or accept the null hypothesis.

32. Catch per unit effort was also used as an index of relative abundance over time to evaluate outmigration timing in Salmon Creek. Catch per unit effort (unit effort = 1 hr of gear deployment) was calculated by dividing the total smolt-net or fyke-net catch of fry for each species by the number of hours the gear was fishing on a given day.

33. The frequency of otolith growth increments was evaluated by counting the increments of known-age fish sampled from the experimental pond. The otoliths of pond fish had a darker discontinuous zone, or transfer check,

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* The use of trade names does not reflect endorsement by the US Fish and Wildlife Service or US Army Engineer Waterways Experiment Station, Vicksburg, MS.

coinciding with the date of capture and introduction into the saltwater pond. This provided a reference point from which to begin evaluating age. The number of growth increments between the check and the periphery of the otolith was interpreted as saltwater age. To confirm daily periodicity of increments in pond fish, increment counts were compared with days of residence in the pond.

34. To identify a reference point on the otoliths indicating the onset of estuarine residence in wild fry, the mean radius from the major nuclei to the beginning of consistent increment formation for wild and pond otoliths was compared with the mean radius from major nuclei to the otolith periphery for fry collected from Salmon Creek. Increment formation and fork length of unknown-age fish were compared with those of known-age fish from the experimental pond.

35. Mean ages were calculated for each fry species by location and date. Increment counts were made for both left and right otoliths, and when different, counts were averaged in calculations for mean age.

PART VI: RESULTS

Inshore Species Composition, Distribution, and Relative Abundance

36. Species composition of beach seine catches totaled 21 taxa which included 5 species of salmon; anadromous Dolly Varden, eulachon (*Thaleichthys pacificus*), and stickleback (*Gasterosteus aculeatus*); 3 species of flatfish; 2 species of sculpin; 5 nearshore benthic species; and 3 nearshore pelagic species (Table 2).

Salmon fry

37. The mean number of fry (both pink and chum salmon, all stations combined) caught per seine haul in 1986 was nearly three times that of the 1987 mean (9.3 versus 3.2, respectively) (Figure 5). This was primarily attributable to a much higher catch of pink salmon (at all stations except Cliff) in 1986 than in 1987 (6.8 versus 0.8 per seine haul, respectively). Catches of chum salmon did not differ as drastically between the 2 years (Figure 6) and averaged 2.5 fish per seine haul each year. For both years, fry catches in seine hauls peaked in the first week of May. In 1986, the increase in mean catches was dramatic between the last week in April and the first week in May; in 1987, the increase was less pronounced (Figure 5). Catches of chum salmon peaked 2 weeks earlier in 1987 than in 1986; catches of pink salmon peaked during the same week both years (Figure 7). Appendix A contains raw seine data for salmon fry.

38. Over all stations, salmon fry were most abundant at Cliff in 1986 (47.4 percent of total catch) and at Noname in 1987 (53.3 percent) (Figures 8 and 9). These stations combined (both are proposed harbor site stations) contributed 57.1 percent of the total fry catch in 1986 and 59.0 percent in 1987.

39. Although this difference in fry catches between harbor and nonharbor stations appeared appreciable, t-test comparisons indicated that no significant difference existed between fry catches at harbor and nonharbor stations at the 0.05 level. When harbor versus nonharbor catches were compared using only combined dates of peak fry catches (4-18 May 1986; 27 April-11 May 1987), differences were again found to be statistically insignificant. However, four of six cases (fry only) approaching significance at the 0.10 level indicate that more years of data may have shown higher catch rates of salmon fry at the project sites (Table 3). Null hypotheses (no difference

exists) were also tested for north (Greenhouse, North, Noname, Cliff) versus south (Lowell Point, Houseboat) stations and east (Greenhouse, Lowell Point) versus west (North, Noname, Cliff, Houseboat) stations using all dates and just peak dates: No significant differences were observed.

40. Pink salmon fry were most abundant at Cliff (mean = 24.8) and least abundant at Noname (mean = 1.8) in 1986, and most abundant at Noname (mean = 2.5) and least abundant at North (mean = 0.1) in 1987. This was probably an artifact of the very low pink salmon catch at all stations in 1987. Chum salmon were most abundant at Lowell Point (mean = 7.3) and least abundant at North (mean = 0.9) in 1986, and most abundant at Noname (mean = 10.7) and least abundant at Cliff (mean 0.5) in 1987.

41. When combining stations to analyze 1987 catches by tide stage, Noname was excluded because it was not sampled during low tide. Differences between high and low tide catches were not consistent over time nor at all stations and proved to be statistically insignificant. When t-test comparisons were used to compare catches by tide (H_o: no difference exists between high and low tide catches), no significant differences were found for pink salmon fry, chum salmon fry, or salmon fry at combined stations for either combined date and peak dates, or at each station for combined dates and peak dates (Table 3). One exception was noted: Low tide catches of chum salmon at Houseboat were significantly higher than high tide catches. The data suggest, however, that the proportion of fish taken at high tide increases through the season, presumably as the fish grow (Figure 10).

<u>Predators</u>

42. The mean number of predators (Dolly Varden, sculpin, and juvenile coho salmon,) caught per seine haul in 1987 was over twice that of the mean catch in 1986 (9.0 versus 4.2, respectively) (Figure 11). Catches of all predator species were higher in 1987, but especially for coho salmon (Figure 12). In 1986, predator catches were highest during the last week of sampling (mid-June), and in 1987, during the first week of June.

43. Fry predators were most abundant at Cliff during both years and were least abundant at Noname in 1986 and at North in 1987 (Figures 13 and 14). Mean catches of predators from harbor stations were significantly higher than those from nonharbor stations in 1987 (Table 3). These differences were not observed for 1986 catches. In addition, no significant difference in

predator catches was observed between north and south stations or between east and west stations.

44. Catches of predators were not significantly different between high and low tides (stations combined), nor were catches of individual predators with two exceptions: catches of sculpins were significantly higher in low tide samples in 1987, and catches of coho salmon were higher in high tide samples in 1986. When stations were analyzed separately, predator catches were significantly higher at high tide at Lowell Point and significantly higher at low tide at North and Houseboat.

Other fishes

45. Of the species collected during beach seining (other than fry or fry predators), herring, sand lance (*Ammodytes hexapterus*), starry flounder (*Platichthys stellatus*), sockeye salmon smolts (*O. nerka*), and eulachon were the most abundant. High catches of herring, eulachon, and sand lance in spawning condition were intermittently observed at Cliff, Houseboat, and Lowell Point. Spawning sand lance were observed during low tide on the exposed mud flats at North during mid-May 1987.

Offshore Juvenile Salmon Distribution

46. No pink or chum salmon fry were captured during offshore tow netting, but up to 250 larval smelt were caught in every tow in 1987. One juvenile coho salmon and one small kelp greenling (*Hexagrammos decagrammus*) were also captured in 1987.

Juvenile Salmon Food Habits

47. The two most consistently occurring food items in both pink and chum salmon stomachs were planktonic calanoid and epibenthic harpacticoid copepods. Dipteran larvae and adults were also common for chum salmon. Other frequently encountered food items included epibenthic amphipods and ostracods and planktonic decapod zoea, *Daphnia* spp., copepod nauplii, and fish larvae. Frequencies of amphipods and ostracods were higher in stomachs of chum salmon than in those of pink salmon. For pink salmon, 88 percent of the stomachs contained epibenthic prey, 79 percent contained planktonic prey, and 67 percent contained both. For chum salmon, 86 percent contained epibenthic prey,

93 percent contained planktonic prey, and 96 percent contained both. There were no appreciable differences in frequencies between harbor and nonharbor stations, but a more diverse array of food items was present in samples from nonharbor stations (see Appendix B).

Predation on Juvenile Salmon

48. In 1986, 33 juvenile coho salmon, 40 Dolly Varden, 31 sculpin, 8 tomcod (*Microgadus proximus*), 17 starry flounder, and 10 sockeye salmon (*O. nerka*) stomachs from Cliff and Noname stations were analyzed for presence of pink or chum salmon fry. Of these, Dolly Varden, coho salmon, and sculpin had eaten fry (Table 4); 20 percent of the Dolly Varden, 9 percent of the coho salmon, and 6 percent of the sculpin stomachs contained fry. Stomach contents (other than fry) of sculpin included shrimp and other crustaceans; of Dolly Varden, included herring and sand lance; and of coho salmon, included crustaceans.

49. In 1987, 66 sculpin, 90 coho salmon, 121 Dolly Varden, 41 tomcod, 23 herring, and 18 sockeye salmon from Cliff and Noname were analyzed for presence of fry; 3 percent of the sculpin, 7 percent of the coho salmon, 6 percent of the Dolly Varden, 2 percent of the tomcod, and none of the herring or sockeye salmon contained fry (Table 4). Predators collected from the second week through the final week of sampling had eaten fry. Only Dolly Varden stomachs contained more than one fry per stomach.

Outmigration Timing

50. Overnight fyke-net catches of up to four fry per hour were observed from early April through early May in 1986. On 5 May, an overnight sample yielded thousands of juvenile salmon. This was considered to be the outmigration peak. After this time, the trap was removed for the rest of the sample period due to the difficulty in operating it for short periods during heavy outmigration. The smolt net, however, could easily be left in operation for short periods during heavy outmigration. After 5 May, smolt-net sampling was continued for short periods until the end of the sampling period, with catches of 8 to 19 fry per hour throughout May (Figure 15).

51. Smolt-net catches of juvenile pink salmon in Salmon Creek were much higher than catches of chum salmon. Catch per hour ranged from 4.3 to 47.3 pink salmon per hour between 20 April and 5 May 1987, with the peak catch occurring on 5 May (Figure 15). Chum salmon catches ranged from 0.3 to 2.3 fish per hour for the same period, with the peak catch occurring on 20 April. Water levels in Salmon Creek rose rapidly after early May. The smolt net did not operate as efficiently then because of clogging with debris and gravel, and it was removed. Outmigration may have continued for a longer period than reported here.

52. Juvenile chum salmon from Salmon Creek samples averaged 39.0 mm in total length with a range of 35 to 42 mm (N = 25). Juvenile pink salmon averaged 32.0 mm with a range of 29 to 34 mm (N = 60).

53. Overnight minnow trapping in Spring Creek and Bear Creek yielded pink and chum salmon fry in late and mid-May 1986. Juvenile salmon catches per trap night by stream were 0.25 and 1.00. Stomachs of juvenile Dolly Varden captured in minnow traps in Salmon Creek and Spring Creek also yielded salmon fry.

Determination of Estuarine Residence Time

54. Plankton tows in the experimental pond yielded extremely abundant quantities of a copepod, *Acartia clausi*, and diatoms. Of the 20 pink and 5 chum salmon fry introduced into the pond for preliminary evaluation of survival, 18 pink and 4 chum salmon remained alive and in good condition after 1 week. Since an adequate food supply appeared to be available and conditions seemed suitable for fry survival, the experimental pond was used for rearing known-age fry.

Frequency of increment formation

55. Salmon fry from the freshwater sampling station in Salmon Creek did not show daily growth increments and were assumed to be zero-age fish. The zone from the major nuclei to the otolith periphery, representing freshwater preemergence growth, was amorphous in these fish (Figure 16).

56. For the known-age pink salmon reared in the experimental pond, growth increments beyond the saltwater transfer check were of regular, consistent intensity, and the number corresponded closely to the number of days in the pond for 6- and 13-day-old fish. This indicated that saltwater growth

increments were deposited daily for the first 13 days (Figure 17). Thereafter, more increments than days in the pond were present, and the increments were of more variable intensity (Figure 18). The fish apparently began to deposit subdaily increments between day 13 and day 20.

57. For otoliths taken from Resurrection Bay salmon fry samples, the mean radius (in micrometres) from the major nuclei to the beginning of consistent increment formation (pink: 8.5, chum: 10.5) differed little from the mean radius from the major nuclei to the otolith periphery for the Salmon Creek fry (pink: 8.6, chum: 10.7). This confirmed the interpretation of the dark check at initial increment formation as a transfer check, indicating entrance to salt water.

58. Increments deposited by Resurrection Bay fish were regular rings of very similar intensity (Figure 19). As with the pond fish, the first increment past the amorphous zone was assumed to have been laid down on the first day postemergence. On the basis of the consistent intensity of increments of the wild fish and the agreement between increment count and age in the pond-reared fish for increments of consistent intensity (to day 13), the investigators concluded that growth increments were daily in both wild pink and wild chum salmon.

Estimated ages of fish rearing in Resurrection Bay

59. Pink salmon moved rapidly through Resurrection Bay. Most fish examined lacked daily growth increments, and very few fish older than 7 days were observed. In contrast, many juvenile chum salmon remained in the Bay for substantially longer periods (Figure 20). The mean age of pink salmon fry (all stations combined) was 0.7 days (range = 0 to 18 days, N = 98 fish) and for chum salmon was 11.8 days (range = 0 to 51 days, N = 203 fish). Pink salmon had the longest residence times at Noname (mean = 1.7 days, N = 25) and the shortest residence times at Greenhouse, North, and Cliff (mean = zero days, N = 11, 4, and 18, respectively). Chum salmon had the longest residence times at Houseboat (mean = 20.6 days, N = 58) and the shortest at North (mean = 5.6 days, N = 20). Age and length data for all aged salmon fry are presented in Appendix C.

Physical and Water Quality Parameters

60. The primary value of the physical data will be for preconstruction and postconstruction comparisons. Appendix D contains all raw physical data.

PART V: DISCUSSION

Summary

61. The lower catch of pink salmon fry in 1987 compared with 1986 probably reflected poor overwintering survival and the occurrence of an extreme autumn flood in 1986, as parent escapements into Salmon Creek were much higher in 1986 (8.3 thousand) than in 1985 (2.1 thousand)(Alaska Department of Fish and Game 1987). High floods are known to especially affect survival of pink salmon eggs, as they are not deposited as deeply as those of other salmon species (Morrow 1980).

62. Fry were most abundant in seine haul catches during the last week in April and the first 3 weeks in May. Because catches of pink salmon rose and fell abruptly and those of chum salmon, more gradually, temporal analysis alone indicated that pink salmon were using the study area as a migration corridor, whereas chum salmon were remaining longer and using it as a nursery or rearing area. These use patterns are similar to those described for these species in southeast Alaska (Cooney et al. 1978), Puget Sound (Levy, Northcote, and Birch 1979), and the Fraser River estuary (Healey 1982).

63. Pink salmon fry have been known to invade estuaries on high tides and leave on the first of ebb tides (Levy, Northcote, and Birch 1979). In contrast, chum salmon have been reported to retreat into tidal creeks during low tide (Mason 1974, Healey 1982). Tidal fluctuations in Resurrection Bay, though greater in magnitude than those elsewhere which affect fry distribution (Healey 1982), appeared to have little significant influence on the nearshore distribution of salmon fry in the study area.

64. Although not significantly different, catches of fry at harbor stations were often greater than those at nonharbor stations. Several orientation and substrate characteristics of the two harbor stations make them favorable habitat for salmon fry. Noname is located adjacent to a braid of the Resurrection River, and Cliff is in the direct path of southeasterly freshwater outflow from the outlet of the river. Because of location and shoreline configuration, these areas probably receive outmigrating salmon fry at a higher frequency than the other stations sampled. In addition, Noname (at high tide) is protected by a promontory to the west and by the mainland shoreline to the east, forming a sheltered, low-current cove. Noname provided

the most sheltered habitat of all the stations. Although composed primarily of silt and sand, substrates at Noname and Cliff also supported beds of eelgrass and sea lettuce not present at the other stations. This vegetation was not obvious early in the sampling period, but became quite dense by mid-May. Salmon fry are known to prefer quiet water with cover-protecting vegetation (Meyer 1979).

65. Predator catches were significantly higher at harbor stations than at nonharbor stations in 1987. Predators may have preferred these areas for some of the same reasons as salmon fry (protective cover) or may have been attracted to the concentrations of salmon fry there as a food source. In addition, outmigrating coho salmon from the Resurrection River (from Alaska Department of Fish and Game fingerling plants) probably pass through the harbor area at a higher frequency than the nonharbor areas. Peak catches of predators corresponded to peak catches of coho salmon and occurred during mid-June in 1986 and early June in 1987. Coho salmon outmigration (from fingerling plants into Bear Lake) usually peaks in mid-June, which was the probable source of the 1986 peak. Coho salmon smolts were also released into Resurrection Bay in late May during both years (more released in 1987 than in 1986) (Vincent-Lang, Bernard, and McBride 1988), which probably resulted in the 1987 peak. Fingerling plants and smolt releases are being increased annually; and as 7 to 9 percent of the coho salmon examined contained pink or chum salmon fry, this could represent a potential impact on fry survival. Coho salmon have been known to have a significant effect on salmon fry survival (Parker 1971, Hargreaves and LeBrasseur 1985).

66. Herring and tomcod are known to be predators of pink and chum salmon fry in southeast Alaska (Thorsteinson 1962), but did not appear to be feeding actively on fry in this study. However, herring were intermittently present in huge quantities at Cliff and Lowell Point, and relatively few were examined. Herring predation may have occurred at a higher rate than detected here.

67. The epibenthic food preferences of pink and chum salmon, well documented elsewhere (Kaczynski et al. 1973, Healey 1979, Godin 1981, Simenstad and Salo 1982), were not apparent in Resurrection Bay. However, very few stomachs, collected over a narrow time span, were analyzed in this study.

68. Further effort to determine the offshore distribution and abundance of salmon fry was not undertaken because of the secondary nature of this

objective (inshore distribution and abundance studies were considered higher priority). The tow net used in this study is efficient gear for capturing sockeye salmon fry in lakes (Flagg et al. 1987). As reported elsewhere (Tyler 1966), a larger net and greater coverage of the bay would have likely produced better results. However, fry may have moved quickly from nearshore areas out of Resurrection Bay.

69. Many previous studies documenting daily growth increments in sagittae of juvenile salmonids have used hatchery fish or fish reared in spawning channels, so the true age of the fish examined was known with a high degree of accuracy (Wilson and Larkin 1980; Marshall and Parker 1982; Neilson and Geen 1982, 1984; Volk et al. 1984). Confirmation of daily growth increments has yet to be done with certainty in wild juvenile salmonids, although Neilson, Geen, and Bottom (1985) sampled juvenile chinook salmon (*O. tshawytscha*) in Oregon and inferred daily growth increments from indirect evidence.

70. The growth increments shown by the pond-reared pink salmon closely matched their time in the pond for the first 13 days of residence. Thereafter, increment count exceeded true age in days (Figure 17). This type of subdaily growth increment deposition has been shown for chinook salmon juveniles fed liberally four times a day (Neilson and Geen 1982). For the first 10 days in Neilson and Geen's study, growth increments matched true age, but shifted into a subdaily pattern as the experiment progressed. During their study, fish that fed once a day deposited an average of one growth increment every 24 hr. The increased increment deposition of the fish fed four times daily was not reflected by increased length, as the two feeding groups showed no significant differences in length.

71. By contrast, pond-reared pink salmon showed increased lengths over their similar-age counterparts sampled from Resurrection Bay (pond pink salmon 20 days old, mean = 53.6 mm; Resurrection Bay pink salmon 18 days old, mean = 43 mm). These growth differences were also evident in chum salmon (pond-reared chum salmon 34 days old, mean = 78.0 mm; Resurrection Bay chum salmon 34 and 35 days old, mean = 52.8 mm).

72. The experimental pond is an artificially productive rearing environment, because it receives nutrient-rich water from 73-m depth in Resurrection Bay (Paul, Hood, and Neve 1976). The high abundance of diatoms and copepods present in this system apparently provided a nearly unlimited food supply for the juvenile salmonids throughout their residence in the pond. The

very rapid growth of the young salmon was accompanied by subdaily growth increment formation on the otoliths after day 13 in the pond.

73. The investigators believe that the increments on otoliths of fish taken from Resurrection Bay were deposited in a daily sequence. The present study has four lines of evidence indicating that daily growth increments occur in wild pink and chum salmon:

- a. The length of the radius from the major nuclei to the transfer or saltwater entry check in the pond-reared pink salmon was nearly identical to the length of the radius from the major nuclei to the otolith edge of the Salmon Creek pink salmon (the zone of preemergent freshwater growth), indicating that the check was deposited on the first day of saltwater (pond) residence, probably within 1 day of emerging from the gravel.
- b. The radius through the freshwater growth zone of both pink and chum salmon from Salmon Creek was about the same distance as the onset of distinct and consistent growth increments found in the wild pink and chum juveniles from Resurrection Bay, indicating that the onset of distinct and consistent growth increments for naturally rearing fish also occurred on the first day of saltwater residence in Resurrection Bay.
- c. Growth increments in pink salmon placed in the pond closely matched residence time for the first 13 days of residence. Growth increments after 13 days were visually distinct from the earlier, daily increments; later increments were not of uniform intensity.
- d. Growth increments in salmon from Resurrection Bay matched the even spacing and uniform intensity of the pond-reared fish during the first 13 days.

74. The freshwater growth zone can be generally characterized as an amorphous region of the ground otolith, lacking uniform incremental growth but including patches of inconsistent ring patterns of variable intensity. The freshwater zone contrasts strongly with the regular pattern of incremental growth shown in the juvenile salmon taken from Resurrection Bay or reared in the experimental pond.

75. Increment counts could be biased. Imprecise grinding can remove outer increments if the otolith is ground too deeply. Also, the edges are occasionally almost translucent, preventing detection of increments that may exist. Contrarily, edges are sometimes darker near the glue-otolith edge interface, potentially masking existing increments. These factors can bias increment count in the direction of underestimating age. The study indicates that this edge effect may cause an underestimate of 1 to 3 days and should be recognized when inferring age in these samples based on increment count.

76. In summary, a case has been made for the deposition of daily growth increments in the otoliths of wild pink and chum salmon juveniles. The most important factor supporting the inference that the increments in Resurrection Bay pink and chum salmon reflect daily growth was the appearance of a distinct regular pattern of incremental growth, similar to that formed in pond-reared fish for the first 13 days of pond residence. A subdaily pattern of incremental growth has been shown for pond-reared pink salmon greater than 13 days old. The irregular subdaily pattern of light and dark rings after 13 days in the pond was not present on the otoliths of fish from Resurrection Bay.

Conclusions

77. During outmigration, pink and chum salmon fry and their predators were often relatively more abundant in the vicinity of the proposed project site than at other areas sampled in upper Resurrection Bay.

78. Tidal fluctuations had little influence in the general nearshore distribution of pink and chum salmon fry and their predators in upper Resurrection Bay.

79. Juvenile pink and chum salmon appeared equally dependent on epibenthic and planktonic food resources during early May in upper Resurrection Bay.

80. Of the three fish groups shown to eat fry (Dolly Varden, coho salmon juveniles, and sculpin), Dolly Varden ate the most juvenile pink and chum salmon.

81. Peak outmigration for juvenile pink and chum salmon occurred during the first week of May in upper Resurrection Bay.

82. Increment formation on pink and chum salmon otoliths apparently began with saltwater entry, and increments were deposited one a day.

83. Pink salmon fry moved rapidly through upper Resurrection Bay, using it as a migration corridor for only several days, while chum salmon remained in the area for up to 1 month.

84. A subdaily pattern of incremental growth was observed for pink salmon fry experimentally reared under optimal prey ration conditions. The subdaily pattern began after 13 days of pond residence and was distinct from the increment patterns of fish taken from Resurrection Bay.

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Table 1

Pink Salmon Escapement and Pink and Chum Salmon Commercial Harvest in Resurrection Bay, Alaska, 1978-1987

Year	Pink Salmon Escapement*	Commercial Catch*	
		Pink Salmon	Chum Salmon
1978	26.1	29.7	0.1
1979	--	0	0
1980	40.7	155.8	0.7
1981	2.7	32.6	2.4
1982	51.9	137.4	7.7
1983	13.6	27.1	6.9
1984	46.5	125.5	3.9
1985	74.7	74.6	3.0
1986	40.7	36.5	3.5
1987	11.6	11.8	13.9
10 Year Avg.	34.2	63.1	4.2

From Alaska Department of Fish and Game (1987).

* Numbers are in thousands.

Table 2

Species List of Fishes Captured in Seine Hauls in Resurrection Bay, Alaska, During 1986 and 1987

Scientific Name	Common Name
Ammodytes hexapterus	Pacific sand lance
Clupea harengus pallasi	Pacific herring
Leptocottus armatus	Pacific staghorn sculpin
Myoxocephalus polyacanthocephalus	Great sculpin
Microgadus proximus	Pacific tomcod
Gasterosteus aculeatus	Threespine stickleback
Hexagrammos decagrammus	Kelp greenling
Osmerus spp.	Smelt
Thaleichthys pacificus	Eulachon
Pholis laeta	Crescent gunnel
Hippoglossoides elassodon	Flathead sole
Lepidopsetta bilineata	Rock sole
Platichthys stellatus	Starry flounder
Oncorhynchus gorbuscha	Pink salmon
Oncorhynchus keta	Chum salmon
Oncorhynchus kisutch	Coho salmon
Oncorhynchus nerka	Sockeye salmon
Oncorhynchus tshawytscha	Kink salmon
Salvelinus malma	Dolly Varden
Anoplarchus purpurescens	High cockscomb
Syngnathus leptorhynchus	Bay pipefish

Table 3

Results from T-Tests Testing Catch Differences Between Tide Stages and Harbor Versus Nonharbor Stations

Fish Group	Mean Catch Per Seine Haul					
	Low Tide	High Tide	P	Harbor Stations	Nonharbor Stations	P
			1986			
Fry						
Pink	6.0	7.5	0.740	13.7	3.4	0.117
Chum	1.7	3.2	0.265	2.8	2.2	0.672
Fry Total	7.7	10.7	0.536	16.5	5.7	0.113
Predators						
Coho	0.7	1.5	0.062	1.5	0.9	0.328
Sculpin spp.	1.5	1.2	0.507	1.0	1.4	0.326
Dolly Varden	1.5	2.0	0.604	1.8	1.8	0.985
Predator Total	3.4	5.0	0.162	4.3	4.1	0.896
			1987			
Fry						
Pink	0.4	0.8	0.470	1.1	0.6	0.590
Chum	1.4	1.9	0.590	3.9	1.9	0.103*
Fry Total	1.7	2.6	0.430	4.9	2.5	0.159
Predators						
Coho	3.1	4.6	0.360	8.7	2.1	0.004**
Sculpin spp.	3.6	0.6	0.001**	5.1	1.0	0.005**
Dolly Varden	2.4	3.5	0.360	1.7	3.2	0.119
Predator Total	9.0	8.7	0.881	15.5	6.1	0.001**

* Significant at 0.05 level.
** Significant at 0.01 level.

Table 4

Number, Percentage, and Fork Length of Predators from Noname and Cliff Seine Hauls Containing Fry, 1986 and 1987

Predator Species	No. Examined	Length Range mm	No. w/Fry %	Mean No. Per Stomach	Length Range w/Fry mm
		1986			
Sculpin spp.	31	60-190	2 (6%)	1.0	75-85
Coho salmon	33	60-120	3 (9%)	1.0	90-100
Dolly Varden	40	110-130	8 (20%)	5.4	115-490
Sockeye	10	70-130	0	0	
Herring	0				
Tomcod	8	100-200	0	0	
Starry flounder	17	90-145	0	0	
		1987			
Sculpin spp.	66	95-145	2 (3%)	1.0	66
Coho salmon	90	60-150	7 (7%)	1.0	75-125
Dolly Varden	121	70-265	7 (6%)	1.6	110-130
Sockeye	18	65-155	0	0	
Herring	23	95-160	0	0	
Tomcod	41	108-240	1 (2%)	1.0	150
Starry flounder	0				

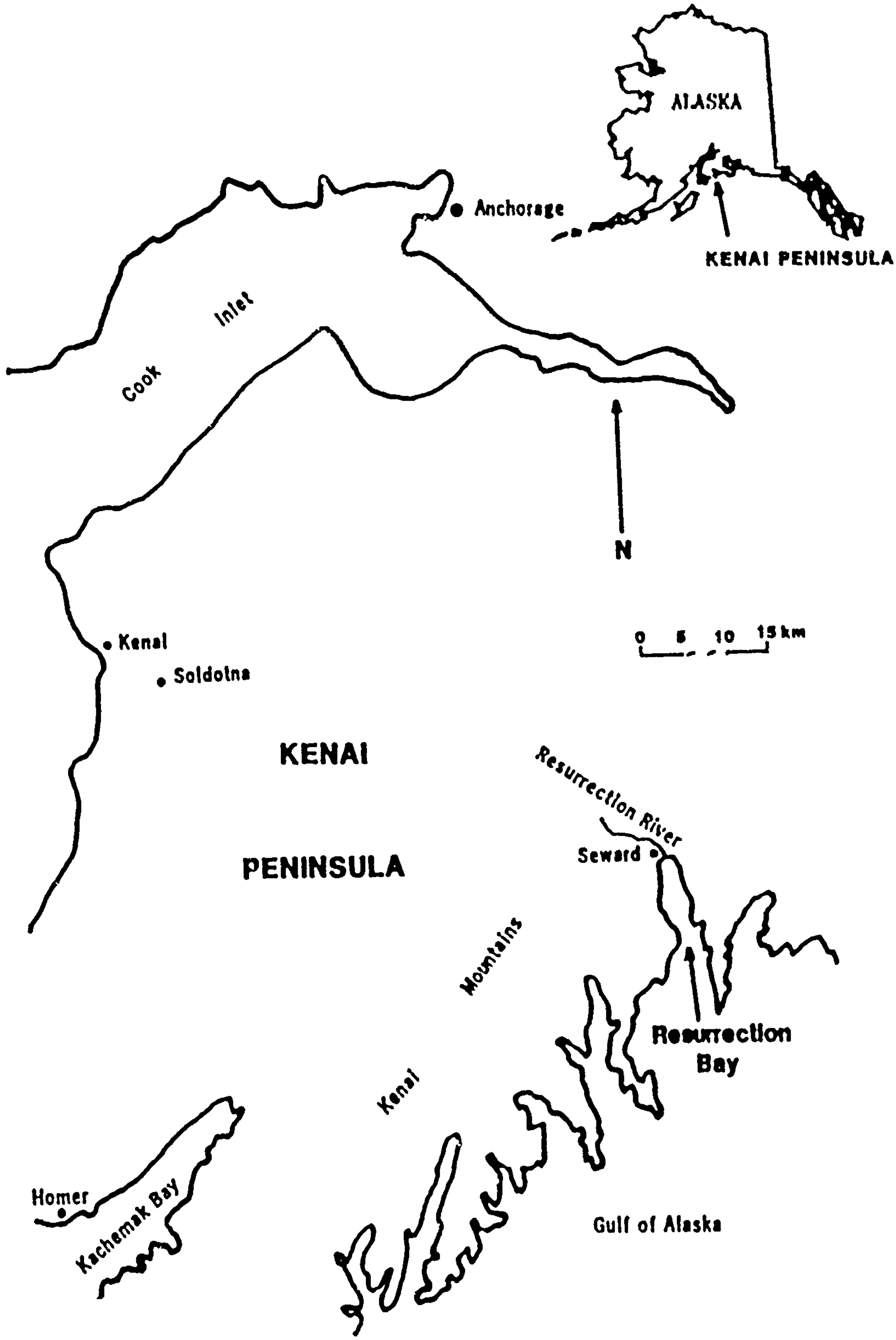


Figure 1. Location map showing Kenai Peninsula and general environments of Resurrection Bay, Alaska

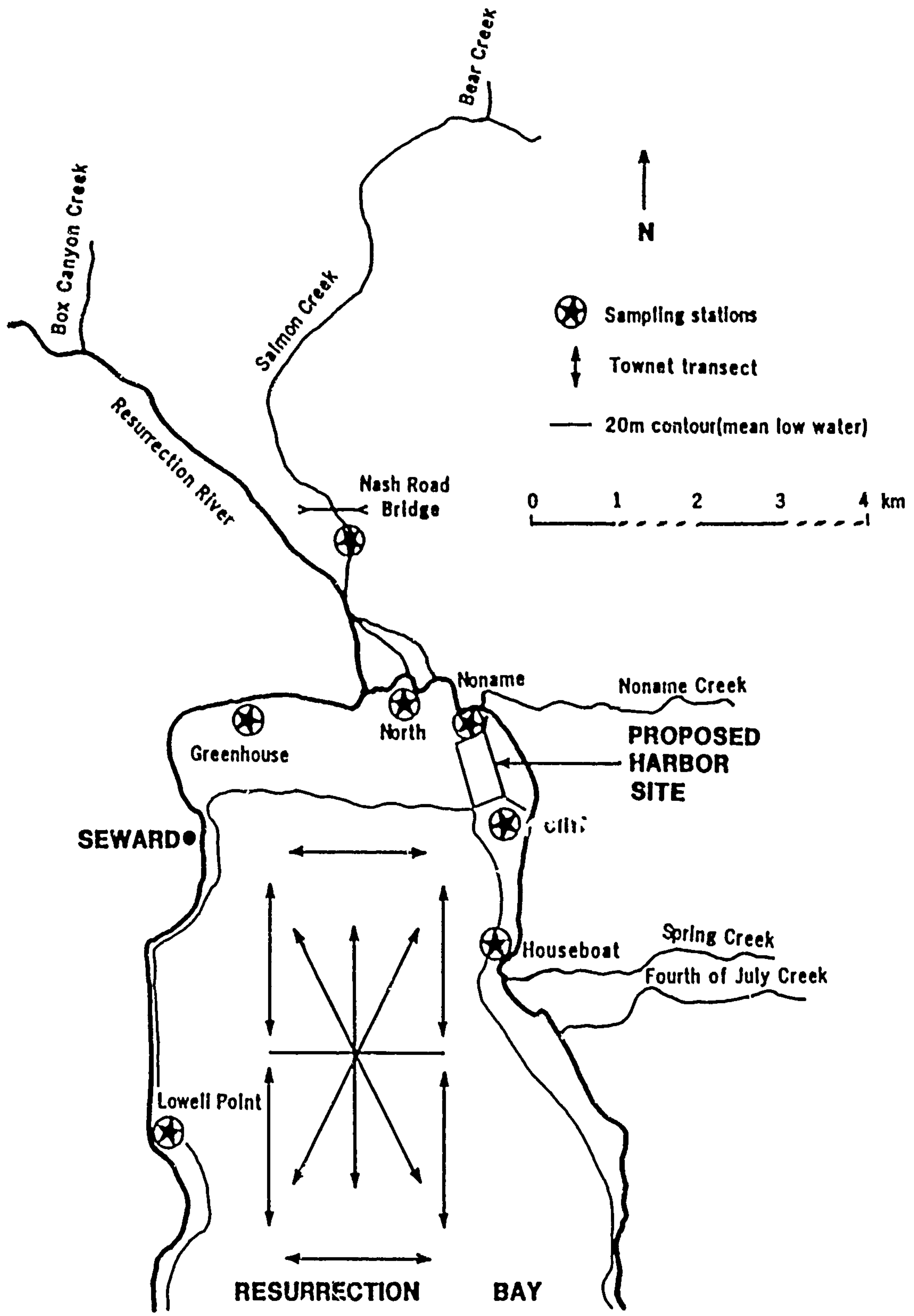
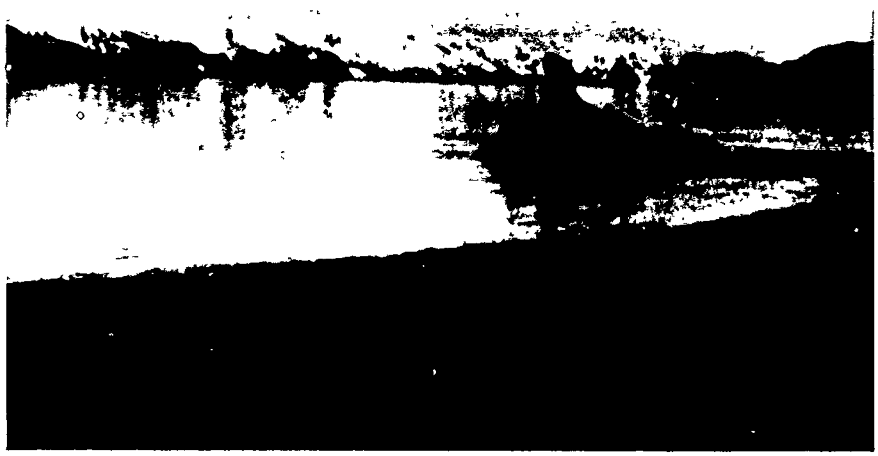


Figure 2. Study area and sampling stations, Resurrection Bay, Alaska, 1986 and 1987

a. Proposed harbor location, lower right, looking north at low tide. Nash Road is at middle right; braids of Resurrection River mouth are at center. North, Noname, and Cliff are visible



b. Lowell Point, looking south down Resurrection Bay

Figure 3. Proposed harbor site and estuarine seine sampling stations, Resurrection Bay, Alaska, 1986 and 1987

(Sheet 1 of 4)

c. Greenhouse, looking northwest along incoming tide toward Seward outskirts and upper Resurrection River

d. North, looking southwest at low tide

Figure 3. (Sheet 2 of 4)

e. Noname, looking west along shoreline, toward Seward and the east side of the promontory that flanks Resurrection River mouth

f. Cliff, looking south down Resurrection Bay

Figure 3. (Sheet 3 of 4)

g. Houseboat, looking north at low tide toward proposed harbor area

Figure 3. (Sheet 4 of 4)

Figure 4. Ground otolith showing (a) major nuclei, (b) dorsal lobe, (c) principal radius, 135 deg from longitudinal axis of otolith

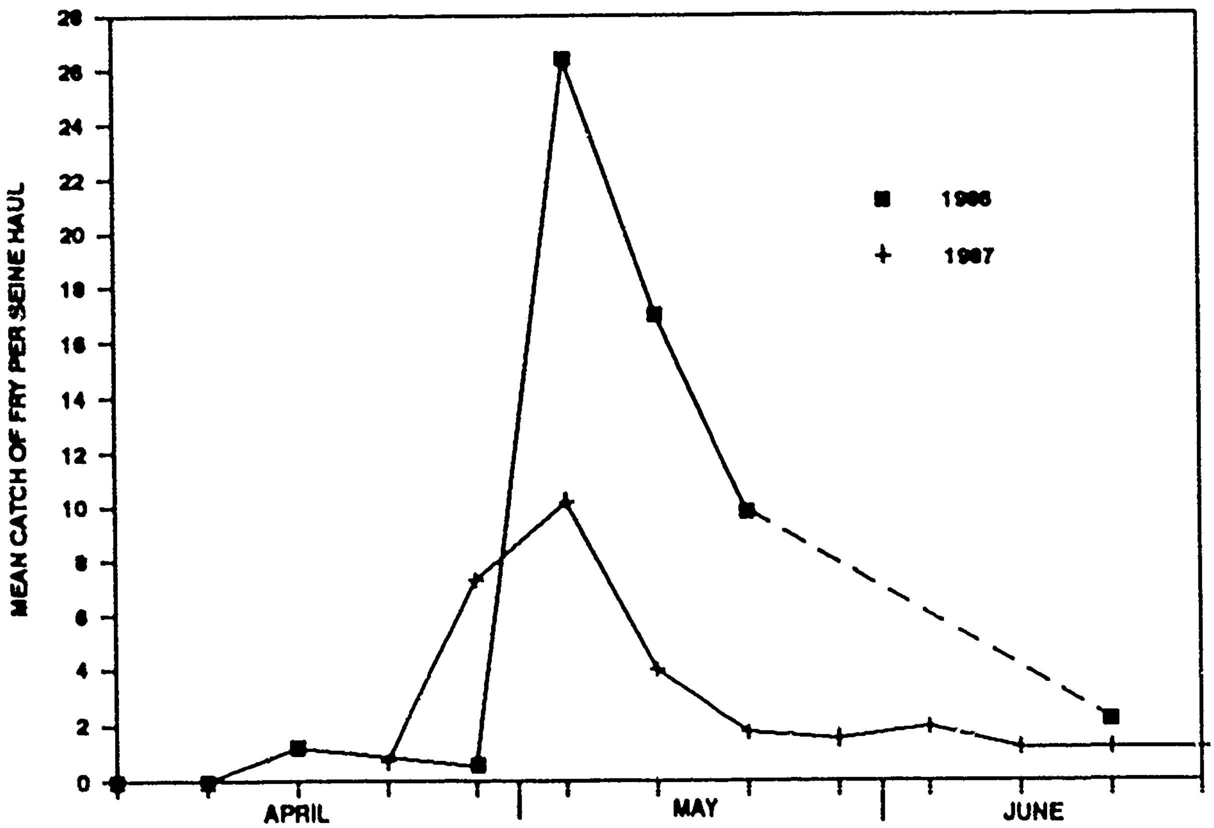


Figure 5. Mean catch per seine haul of salmon fry (pink and chum combined), all stations and tide stages combined, Resurrection Bay, Alaska, 1986 and 1987. Broken lines indicate that no samples were taken during that period

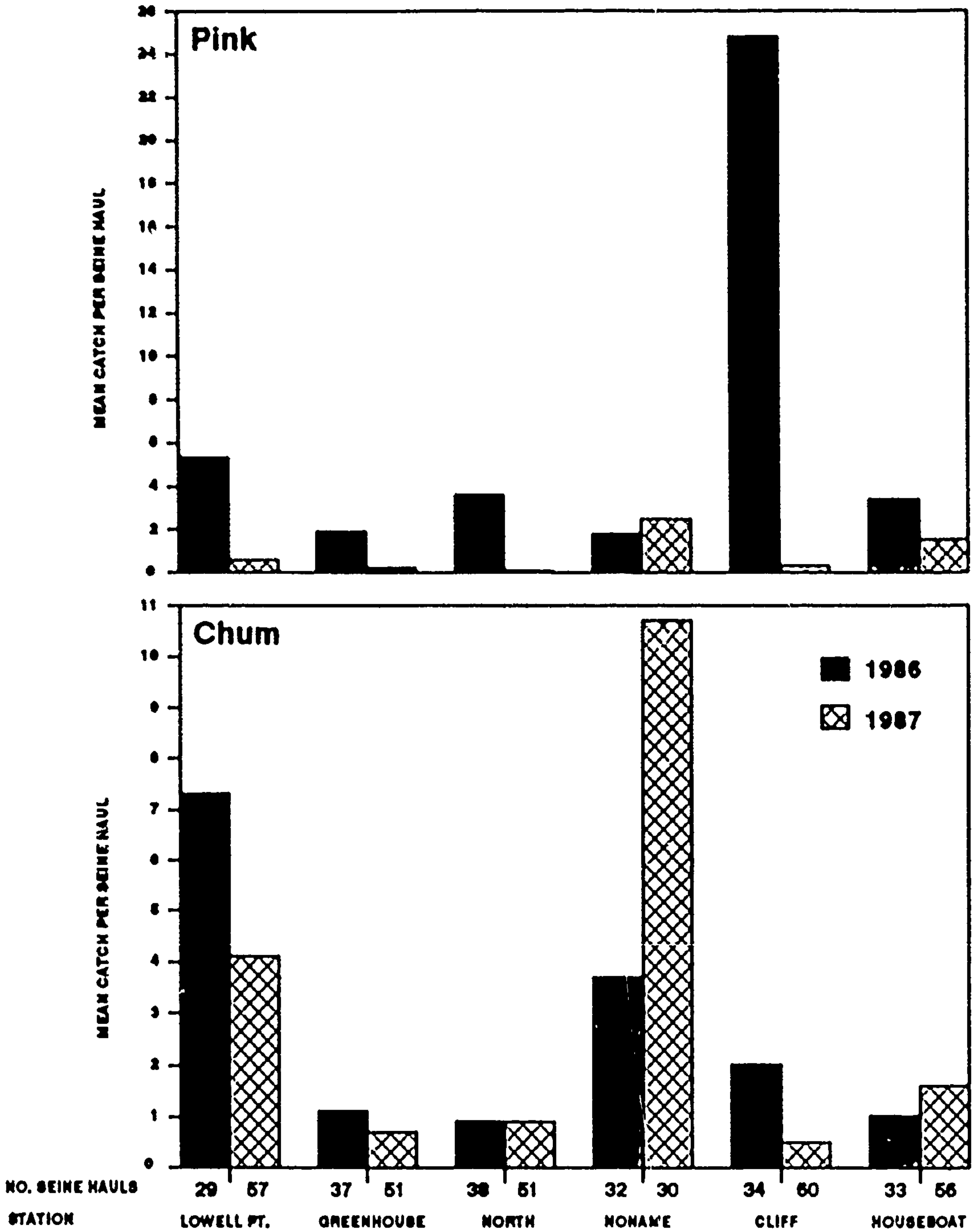
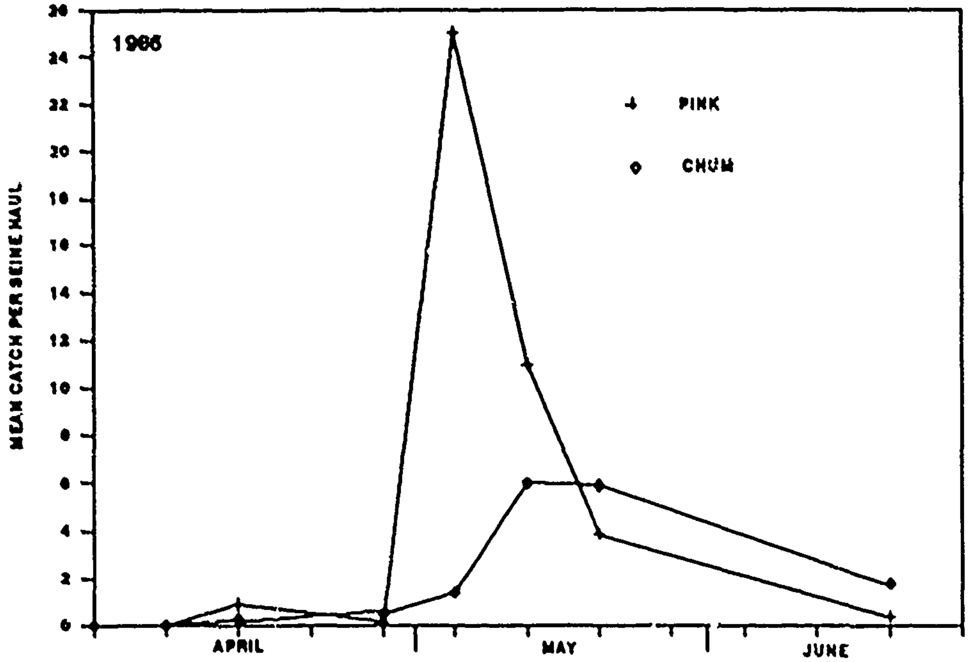


Figure 6. Mean catch per seine haul of salmon fry by station; dates and tide stages combined, Resurrection Bay, Alaska, 1986 and 1987



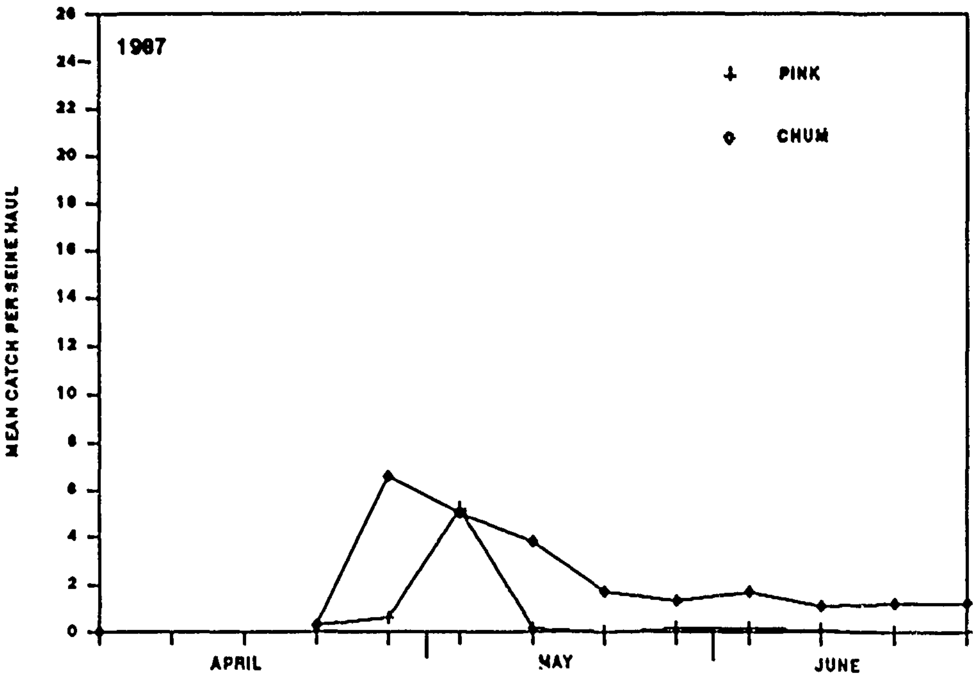


Figure 7. Mean catch per seine haul of pink and chum salmon, all stations and tide stages combined, Resurrection Bay, Alaska, 1986 and 1987

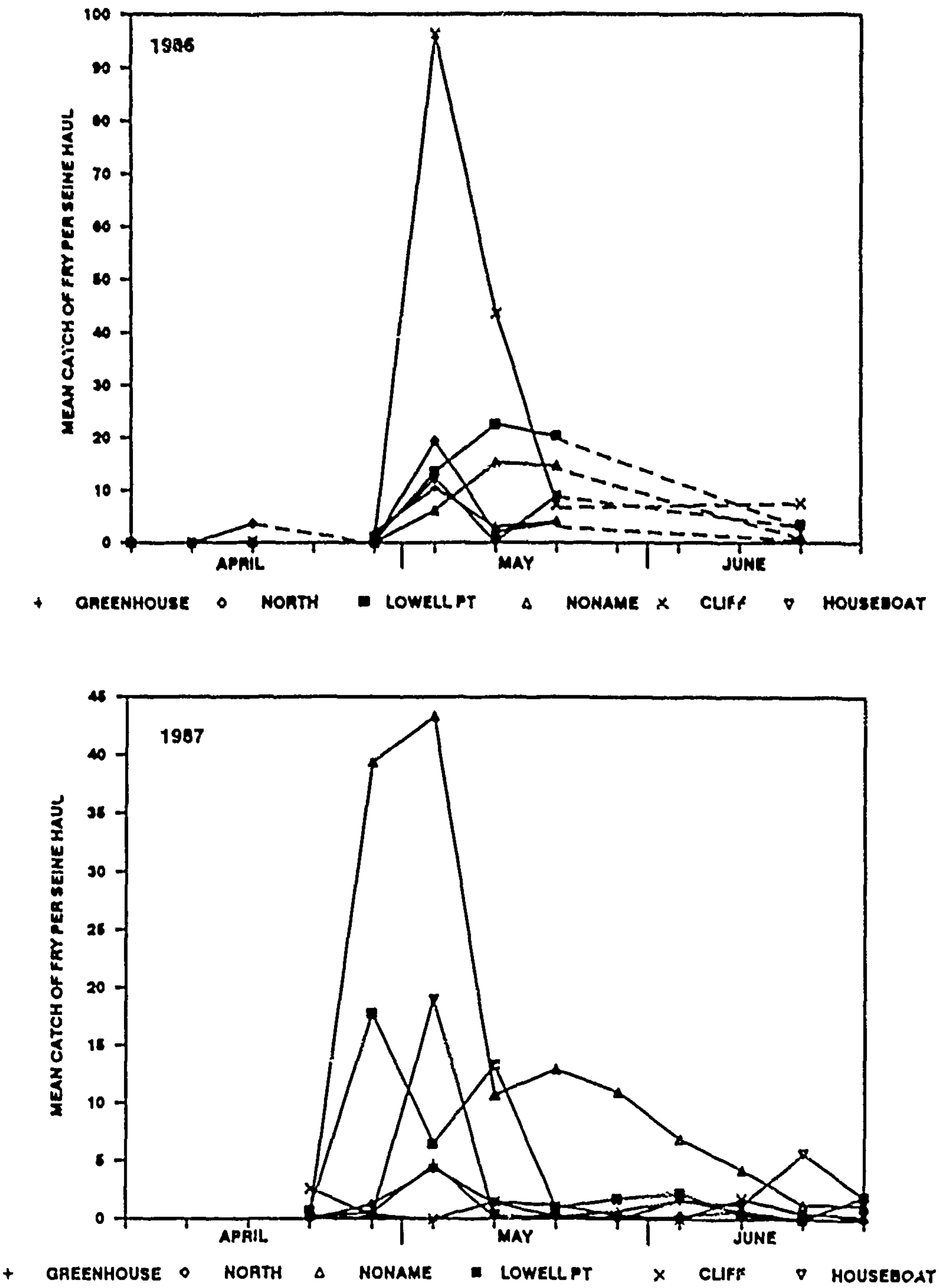


Figure 8. Mean catch per seine haul of combined pink and chum salmon fry by station and date, tide stages combined, Resurrection Bay, Alaska, 1986 and 1987

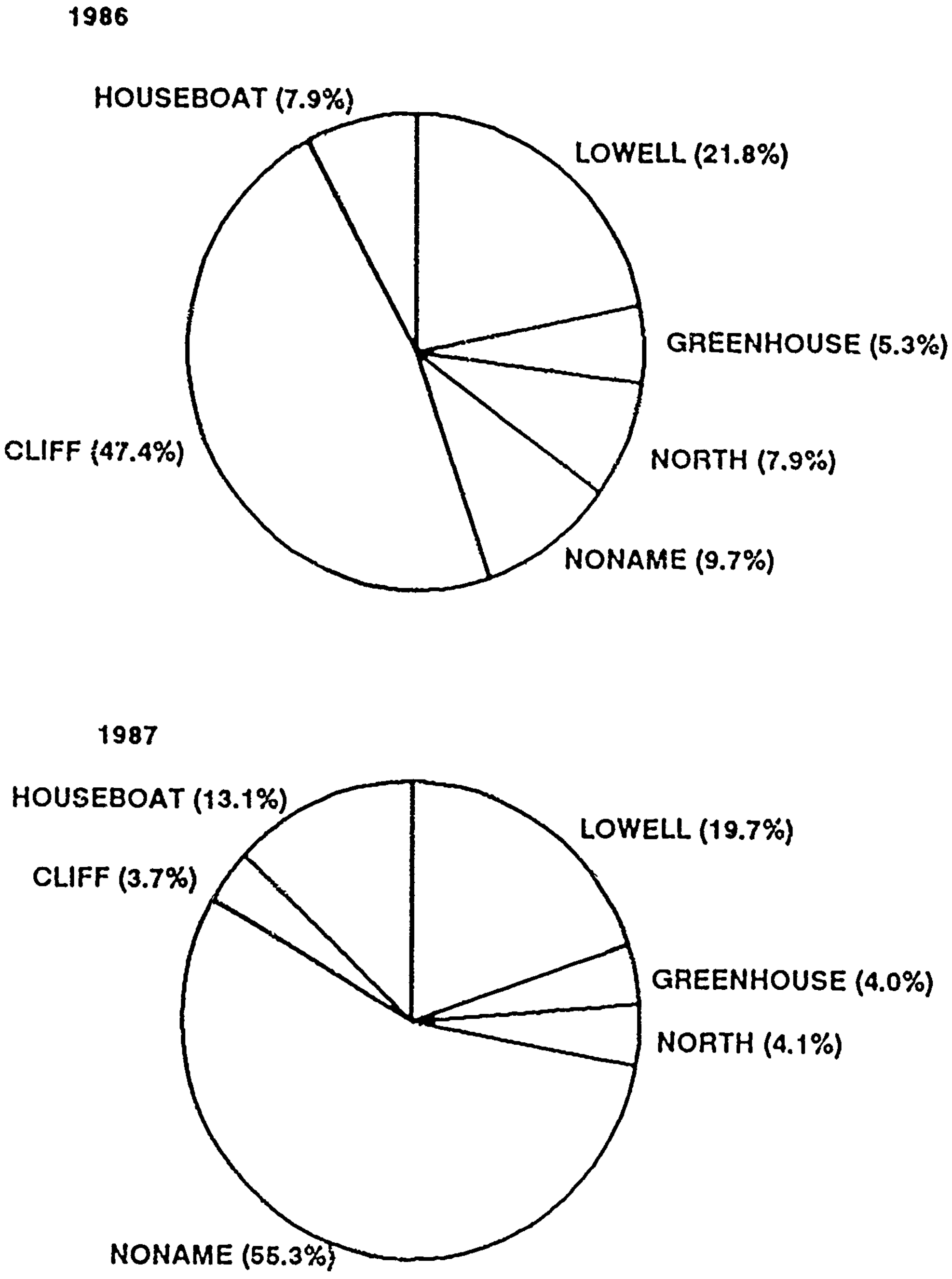


Figure 9. Percentage catch per seine haul of combined pink and chum salmon fry by station, all dates and tide stages combined, Resurrection Bay, Alaska, 1986 and 1987

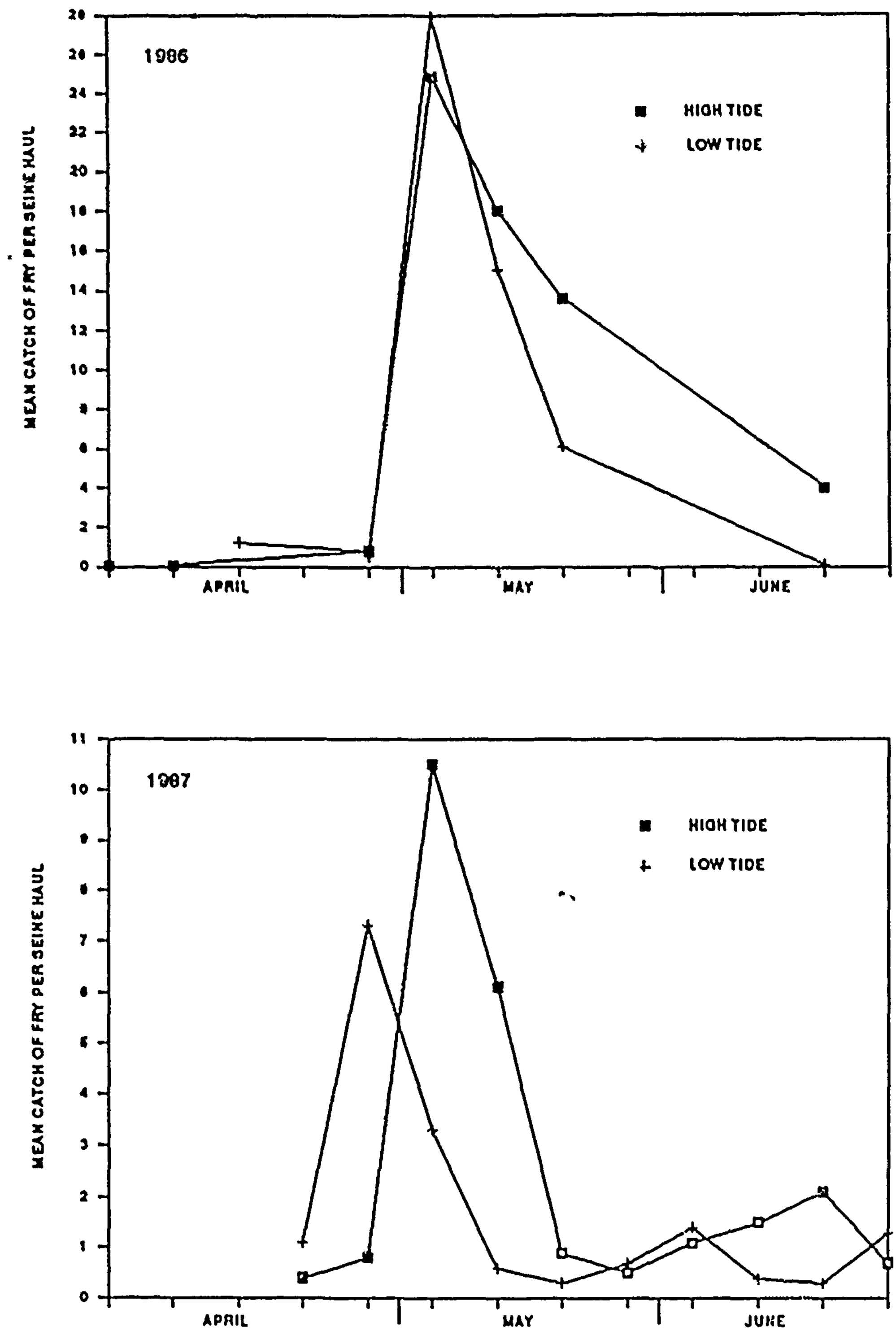
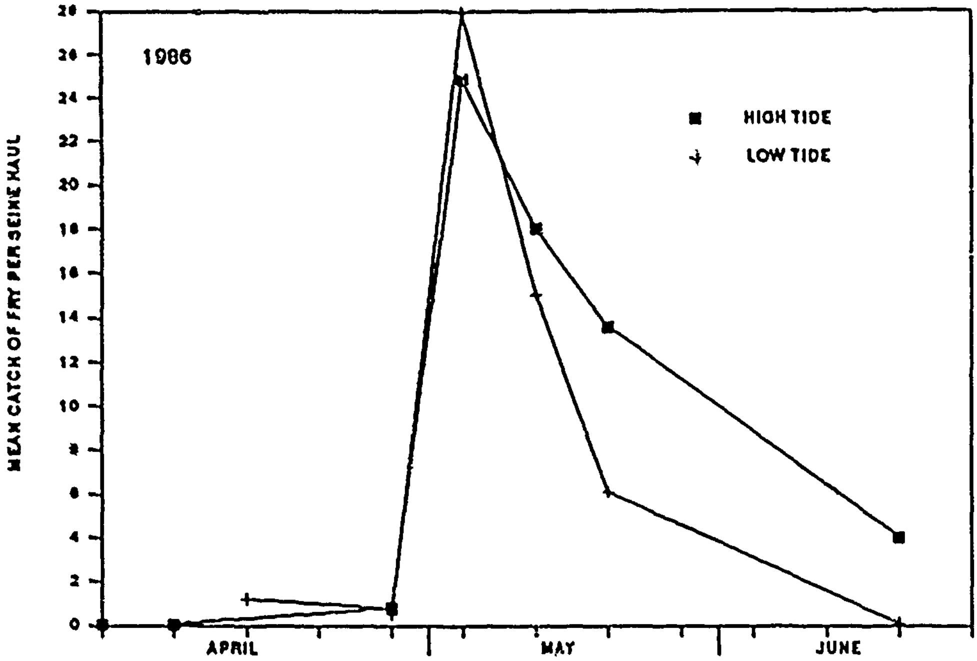


Figure 10. Mean catch per seine haul of combined pink and chum salmon fry by tide stage, all locations combined, Resurrection Bay, Alaska, 1986 and 1987



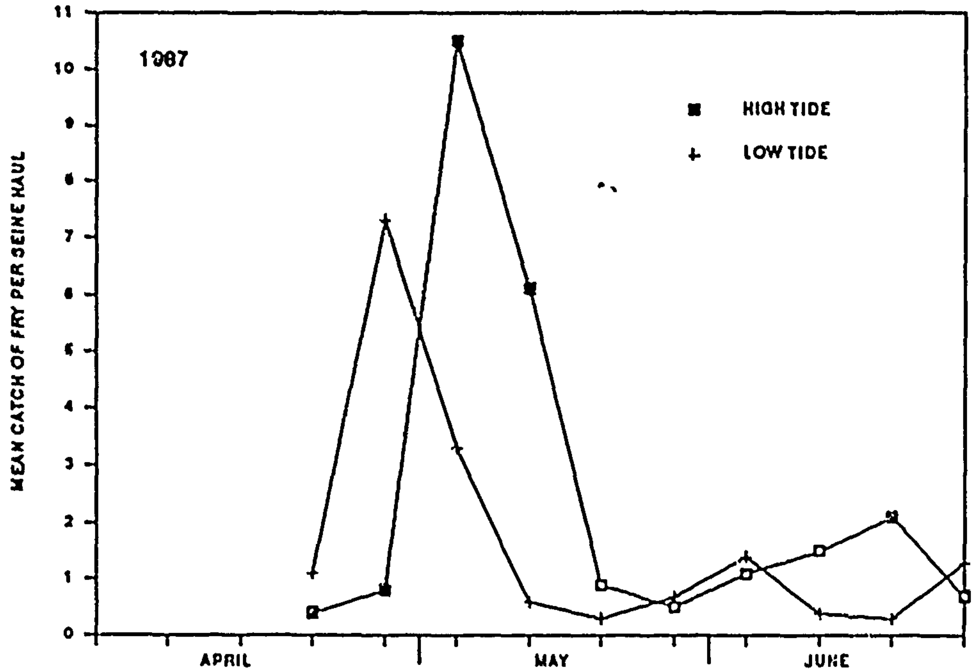


Figure 10. Mean catch per seine haul of combined pink and chum salmon fry by tide stage, all locations combined, Resurrection Bay, Alaska, 1986 and 1987

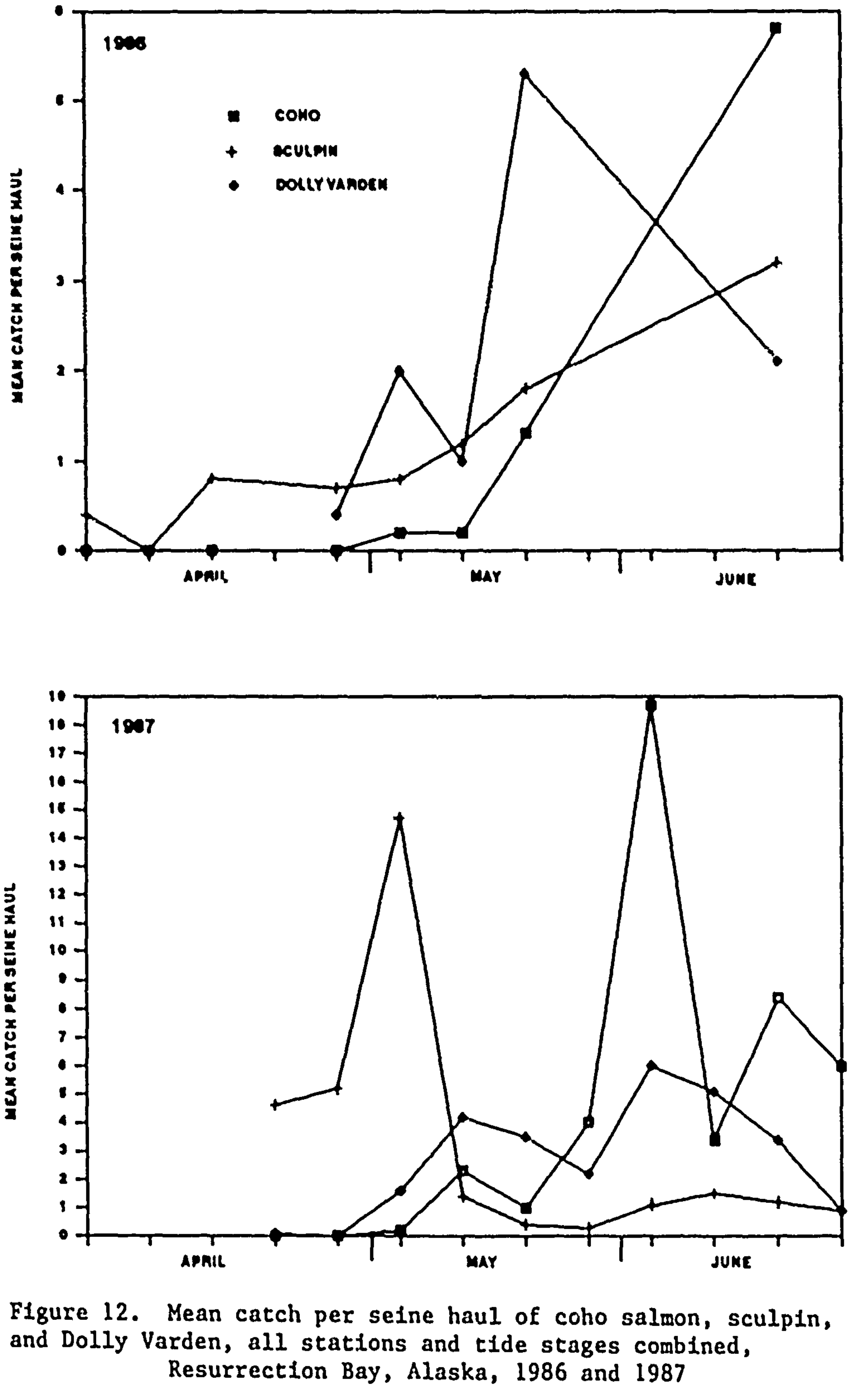


Figure 12. Mean catch per seine haul of coho salmon, sculpin, and Dolly Varden, all stations and tide stages combined, Resurrection Bay, Alaska, 1986 and 1987

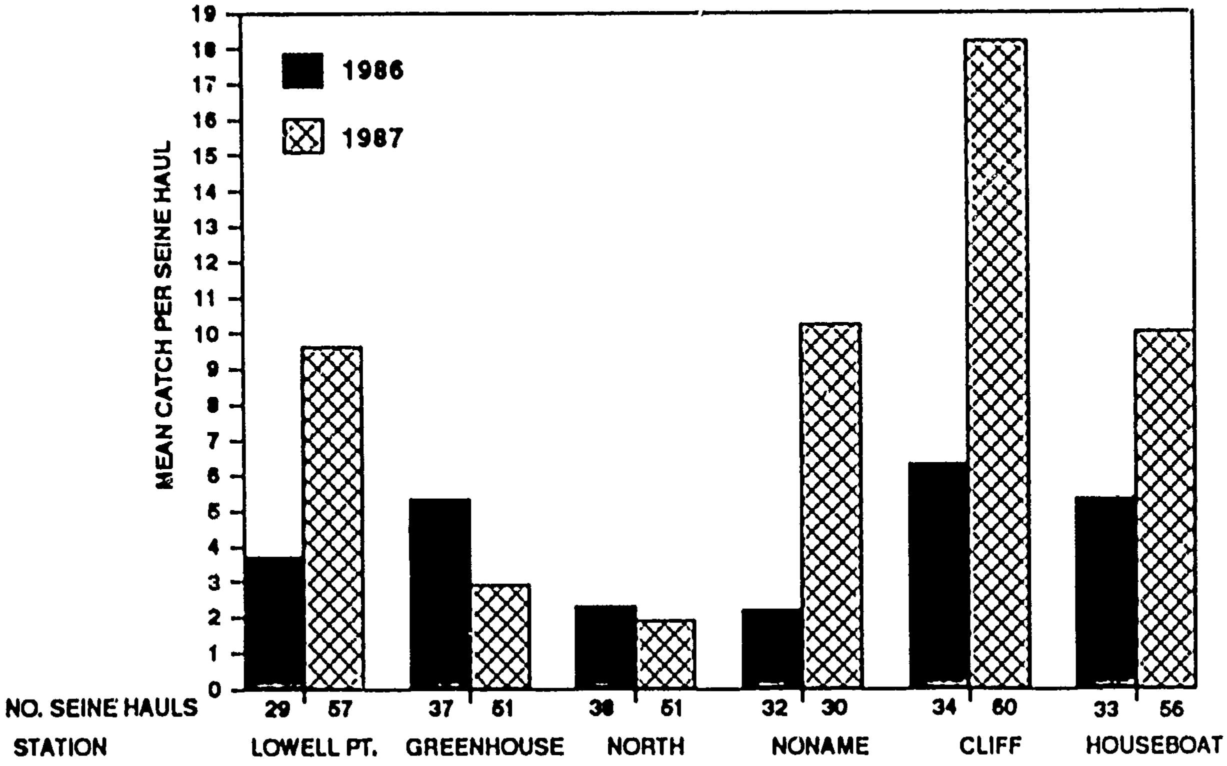


Figure 13. Mean catch per seine haul of combined predators (coho salmon, sculpin, and Dolly Varden) by station, dates and tide stages combined, Resurrection Bay, Alaska, 1986 and 1987

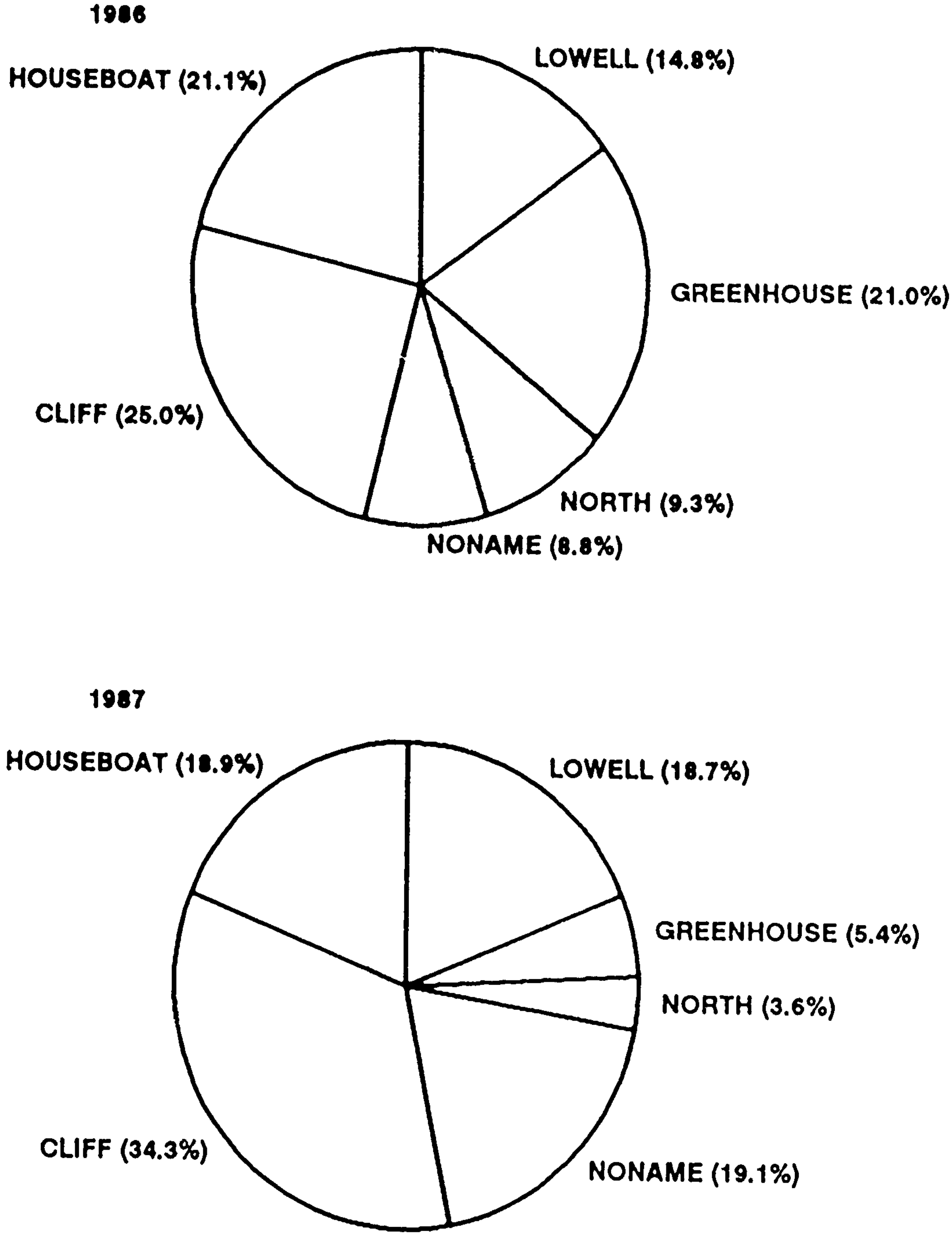
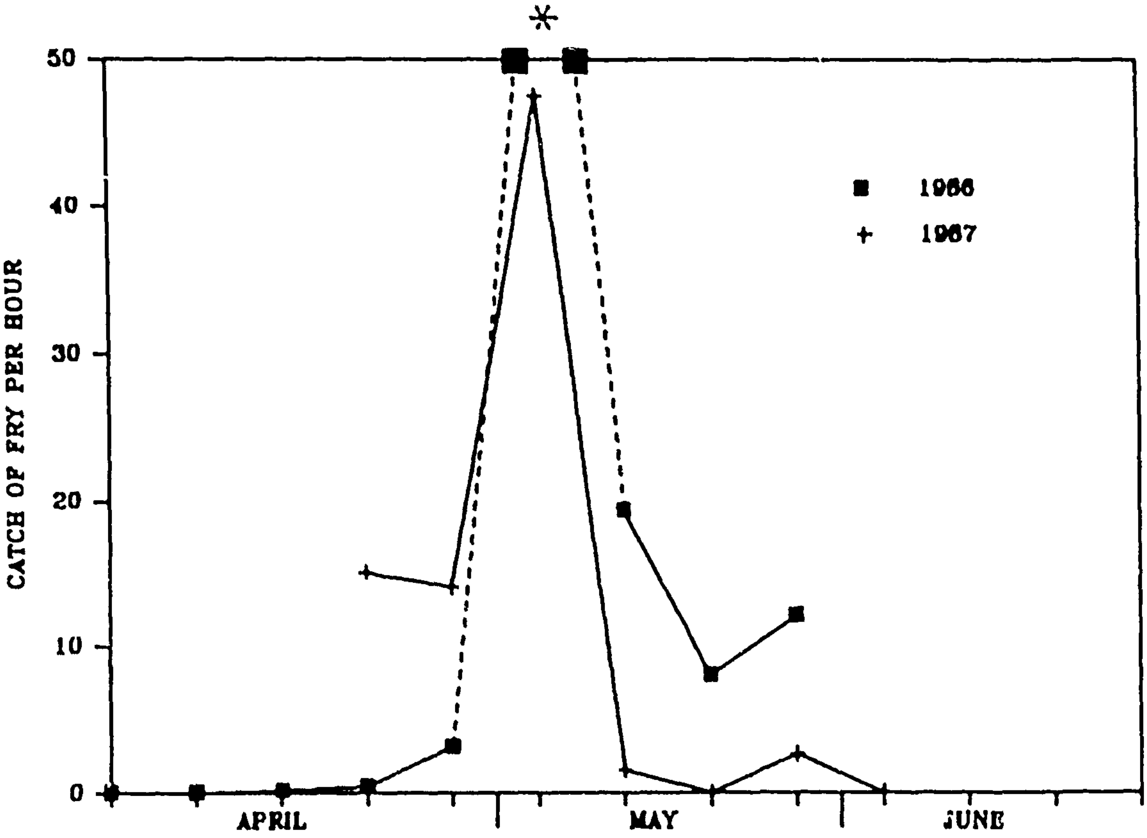


Figure 14. Percentage catch per seine haul of combined fry predators (coho salmon, sculpin, Dolly Varden) by station, all dates and tide stages combined, Resurrection Bay, Alaska, 1986 and 1987



* Sample was uncountable, and estimated at over 1,000 fry per hour

Figure 15. Mean catch per hour of pink and chum salmon fry (combined) from the Salmon Creek smolt net, lower Resurrection River area, Alaska, 1986 and 1987. Broken lines indicate that catch for one sample was extremely high and off scale for this graph

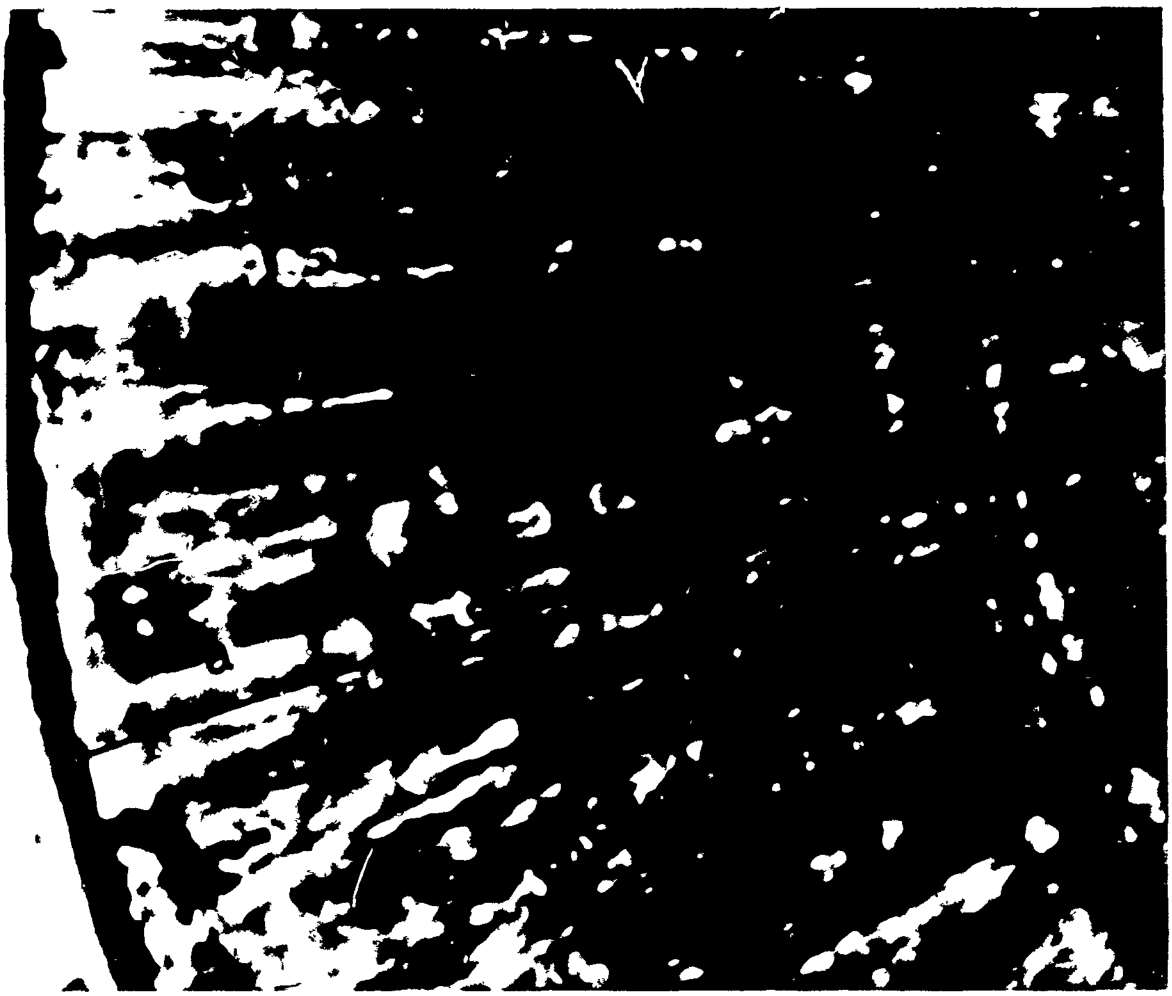


Figure 16. Ground otolith of a chum salmon fry from Salmon Creek showing the amorphous zone (a)

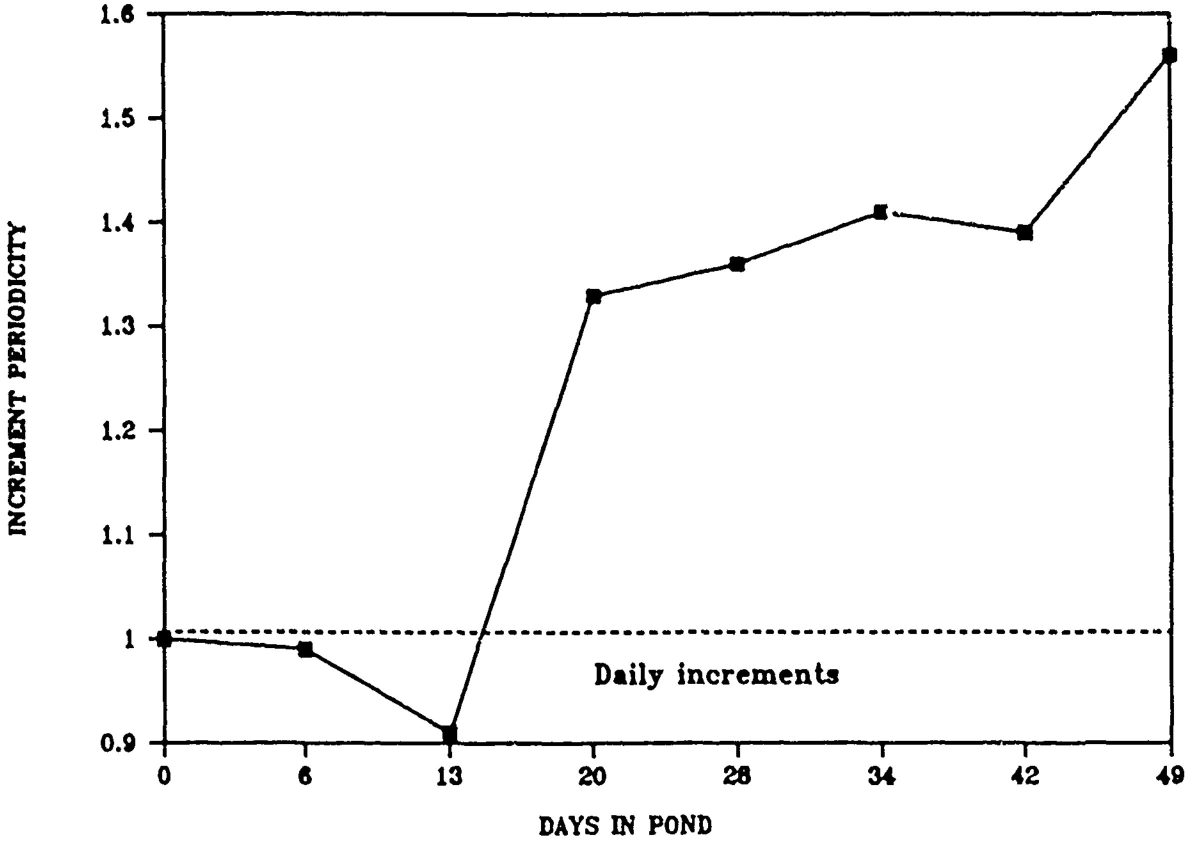


Figure 17. Otolith increment periodicity for known-age pink salmon reared in an experimental pond, plotted against residence time (true age)

Figure 18. Ground otolith of a 20-day-old, pond-reared pink salmon: (1) saltwater transfer check, (2) zone of daily growth increments of consistent intensity to day 13, (3) zone of subdaily growth increments of variable intensity

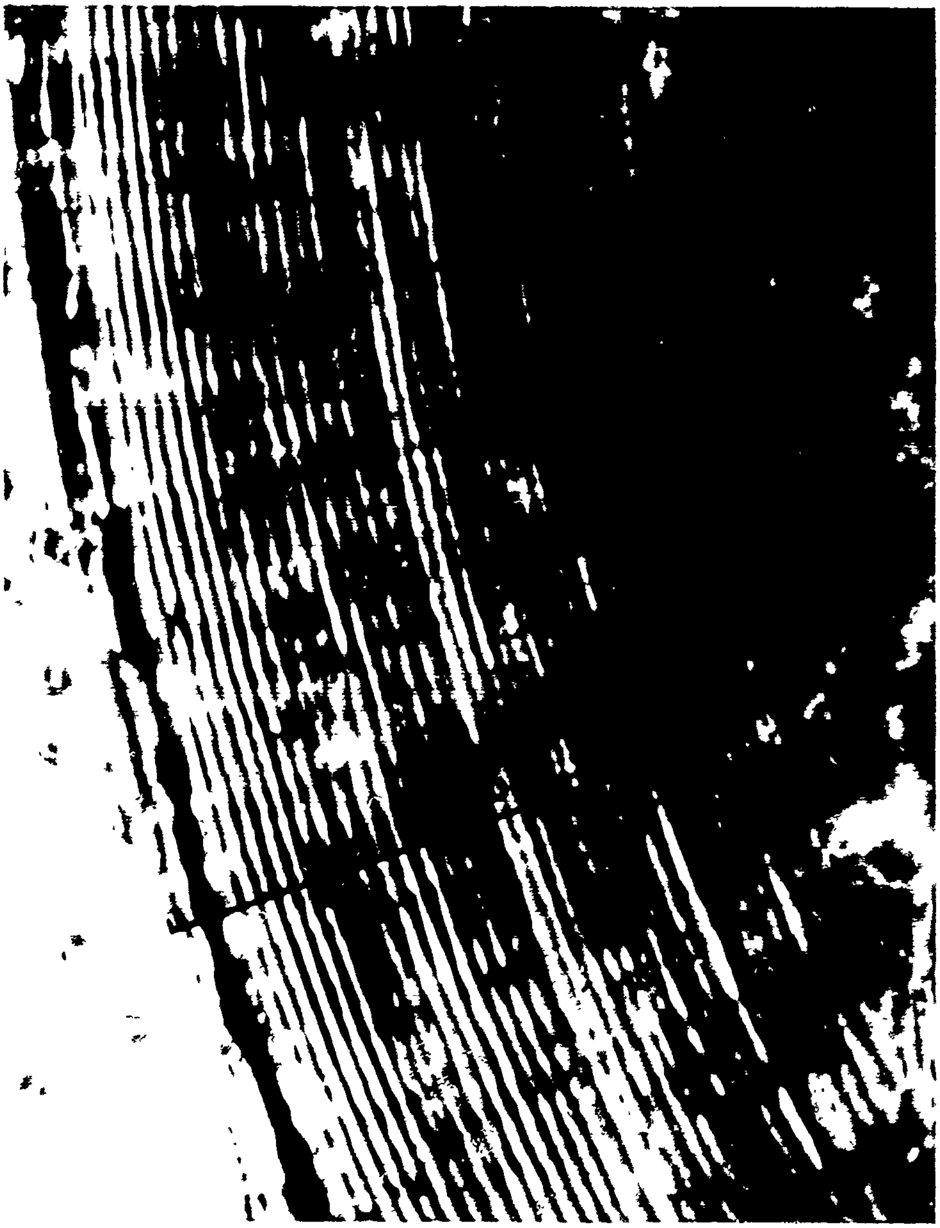


Figure 19. Ground otolith of Resurrection Bay chum salmon: (a) amorphous zone and (b) zone of daily growth increments

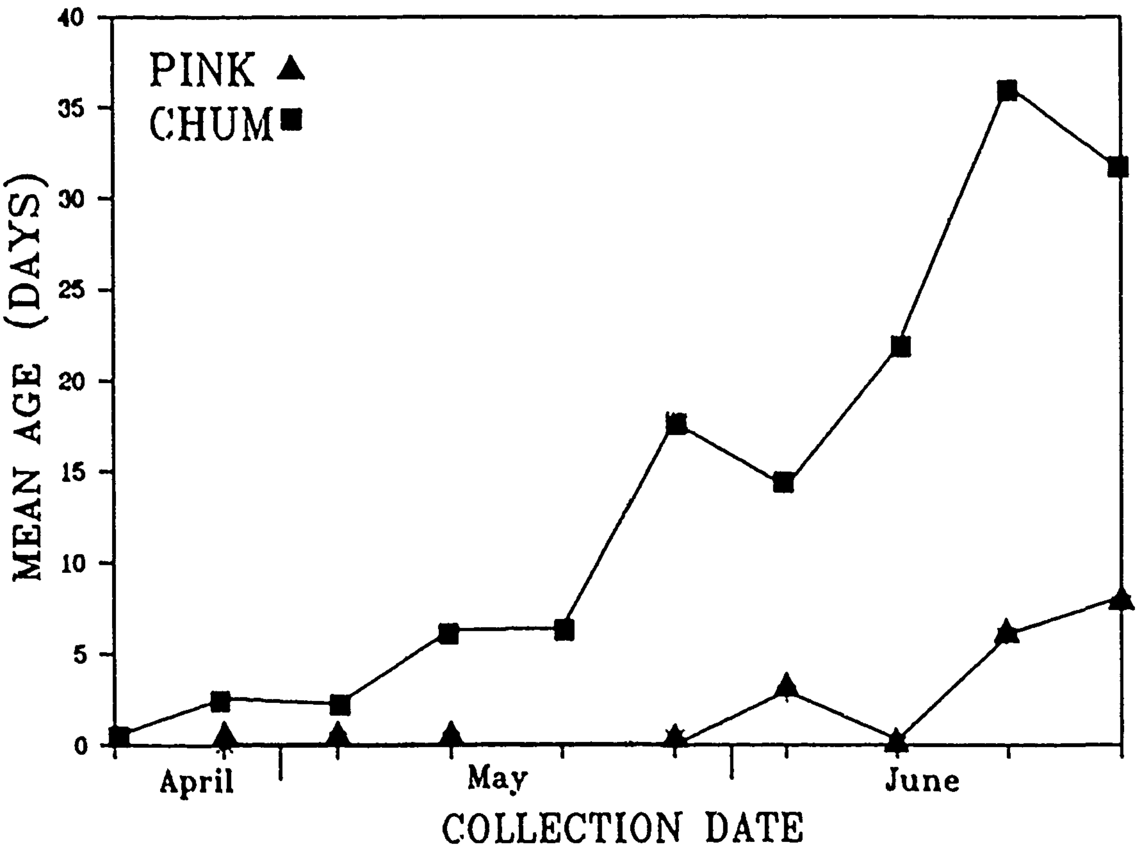


Figure 20. Mean ages (inferred from otolith analysis) of pink and chum salmon fry from Resurrection Bay, Alaska, by collection date, 1987

APPENDIX A: MEAN CATCHES OF SALMON FRY BY LOCATION, DATE, AN [illegible]IDE STAGE

1986

BREAKDOWN OF PINK - PINK SALMON
ACROSS - LOC - LOCATION
DOWN - DATE - WEEK OF SAMPLE DATE

LOW TIDE

M, SD, N	LOWELL PT 1.	GREENHOUSE 2.	NORTH 3.	NONAME 4.	CLIFF 5.	HOUSEBOAT 6.	TOTAL
1.	0	.0 .0 3	.0 .0 3	0	.0 .0 1	0	.0 .0 7
2.	0	0	0	0	0	0	0
3.	0	.2 .4 6	2.7 3.6 6	.2 .4 6	.0 .0 3	0	.9 2.2 21
4.	0	.0 .0 3	.0 .0 3	.0 .0 3	1.3 2.3 3	.3 .6 3	.3 1.0 15
5.	25.7 44.5 3	2.3 1.2 3	37.7 65.2 3	2.7 3.8 3	82.7 64.9 3	6.0 4.4 3	26.2 45.7 18
6.	11.3 19.6 3	0	0	0	.0 .0 3	.0 .0 3	3.8 11.3 9
7.	3.0 2.6 3	3.3 4.9 3	2.0 1.0 3	.0 .0 3	6.0 4.6 3	12.3 14.6 3	4.4 6.9 18
8.	.0 .0 2	.0 .0 3	.0 .0 3	.0 .0 3	0	.5 .7 2	.1 .3 13
TOTAL	10.9 24.1 11	.9 2.1 21	6.4 24.5 21	.5 1.7 18	16.9 40.4 16	4.1 7.8 14	6.0 21.6 101

BREAKDOWN OF PINK - PINK SALMON
ACROSS - LOC - LOCATION
DOWN - DATE - WEEK OF SAMPLE DATE

HIGH TIDE

M, SD, N	LOWELL PT 1.	GREENHOUSE 2.	NORTH 3.	NONAME 4.	CLIFF 5.	HOUSEBOAT 6.	TOTAL	
1.	.0 .0 3	0	0	0	0	.0 .0 1	.0 .0 4	APRIL 3-4
2.	0	.0 .0 1	.0 .0 2	.0 .0 1	.0 .0 3	.0 .0 3	.0 .0 10	APRIL 9-10
3.	0	0	0	0	0	0	0	APRIL 14-16
4.	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.3 .6 3	.1 .2 18	APRIL 28 - MAY 1
5.	.7 1.2 3	17.3 24.9 3	.3 .6 3	7.7 5.5 3	100.3 172.9 3	16.3 28.6 3	23.8 70.5 18	MAY 6-9
6.	.0 .0 3	.0 .0 3	.0 .0 3	2.7 3.1 3	85.0 146.4 3	.3 .6 3	14.7 39.7 18	MAY 12-24
7.	8.3 12.7 3	.0 .0 3	.0 .0 3	6.3 11.0 3	5.0 1.0 3	.7 .6 3	3.4 6.7 18	MAY 19-22
8.	2.0 3.5 3	.0 .0 3	.0 .0 3	.0 .0 3	.7 1.2 3	1.0 1.7 3	.7 1.7 16	JUNE 18-20
TOTAL	1.8 5.5 18	3.3 11.5 16	.1 .2 17	3.6 5.9 14	31.8 89.6 18	2.9 10.7 19	7.3 39.1 102	

1986

BREAKDOWN OF CHUN - CHUN SALMON
ACROSS - LOC - LOCATION
DOWN - DATE - WEEK OF SAMPLE DATE

LOW TIDE

M, SD, N	LOWELL PT 1.	GREENHOUSE 2.	NORTH 3.	NONAME 4.	CLIFF 5.	HOUSEBOAT 6.	TOTAL
1.	0	.0 .0 3	.0 .0 3	0	.0 .0 1	0	.0 .0 7
2.	0	0	0	0	0	0	0
3.	0	.0 .0 6	1.0 2.4 6	.0 .0 6	.3 .6 3	0	.3 1.3 21
4.	0	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.7 1.2 3	.1 .5 15
5.	.7 .6 3	.7 1.2 3	.3 .6 3	.0 .0 3	9.0 6.9 3	.0 .0 3	1.8 4.1 18
6.	33.7 54.8 3	0	0	0	.0 .0 3	.0 .0 3	11.2 32.2 9
7.	4.0 3.0 3	3.3 4.9 3	2.3 1.5 3	.0 .0 3	.0 .0 3	.3 .6 3	1.7 2.7 18
8.	.0 .0 2	.0 .0 3	.0 .0 3	.0 .0 3	0	.0 .0 2	.0 .0 13
TOTAL	10.5 28.8 11	.6 2.0 21	.7 1.6 21	.0 .0 18	1.8 4.4 16	.2 .6 14	1.7 9.8 101

BREAKDOWN OF CHUN - CHUN SALMON
ACROSS - LOC - LOCATION
DOWN - DATE - WEEK OF SAMPLE DATE

HIGH TIDE

M, SD, N	LOWELL PT 1.	GREENHOUSE 2.	NORTH 3.	NONAME 4.	CLIFF 5.	HOUSEBOAT 6.	TOTAL	
1.	.0 .0 3	0	0	0	0	.0 .0 1	.0 .0 4	APRIL 3-4
2.	0	.0 .0 1	.0 .0 2	.0 .0 1	.0 .0 3	.0 .0 3	.0 .0 10	APRIL 9-10
3.	0	0	0	0	0	0	0	APRIL 14-16
4.	.3 .6 3	4.0 4.0 3	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.7 2.1 18	APRIL 28 - MAY 1
5.	.0 .0 3	.7 .6 3	.3 .6 3	2.0 1.7 3	.7 .6 3	2.3 3.2 3	1.0 1.6 18	MAY 6-9
6.	.0 .0 3	3.0 5.2 3	2.0 1.7 3	12.7 12.5 3	2.3 3.2 3	.0 .0 3	3.3 6.5 18	MAY 12-14
7.	25.3 43.9 3	1.7 1.5 3	3.3 3.1 3	23.0 19.1 3	3.3 4.2 3	4.3 5.9 3	10.2 19.5 18	MAY 19-22
8.	4.0 4.4 3	.3 .6 3	1.0 1.7 3	9.0 .0 1	7.0 4.4 3	3.7 3.8 3	3.3 3.6 16	JUNE 18-20
TOTAL	4.9 17.9 18	1.8 2.9 16	1.2 1.9 17	8.4 12.9 14	2.2 3.5 18	1.6 3.2 19	3.2 9.3 102	

1987

BREAKDOWN OF PINK - PINK SALMON
ACROSS - LOC - LOCATION
DOWN - DATE - DATE

LOW TIDE

M,SD,N	LOWELL 1.	GREENHOUSE 2.	NORTH 3.	CLIFF 5.	HOUSEBOAT 6.	TOTAL
1.	.0 .0 3	.0 .0 3	.0 .0 3	2.7 3.8 3	.0 .0 3	.5 1.8 15
2.	1.7 2.1 3	.0 .0 3	.3 .6 3	.3 .6 3	.0 .0 3	.5 1.1 15
3.	4.0 6.1 3	1.7 1.5 3	.0 .0 3	.0 .0 3	2.0 1.7 3	1.3 2.9 15
4.	.0 .0 3	.0 .0 3	.3 .6 3	.7 1.2 3	.0 .0 3	.2 .6 15
5.	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 15
6.	.7 .6 3	.3 .6 3	.0 .0 3	.0 .0 3	.0 .0 3	.2 .4 15
7.	.7 .6 3	0	0	.0 .0 3	.0 .0 3	.2 .4 9
8.	.3 .6 3	.0 .0 3	.0 .0 3	.3 .6 3	.0 .0 3	.1 .4 15
9.	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 15
10.	.0 .0 3	0	0	.0 .0 3	.0 .0 3	.0 .0 9
TOTAL	.7 2.1 30	.3 .7 24	.1 .3 24	.4 1.3 30	.2 .8 30	.3 1.3 138

HIGH TIDE

M,SD,N	LOWELL 1.	GREENHOUSE 2.	NORTH 3.	NONAME 4.	CLIFF 5.	HOUSEBOAT 6.	TOTAL	
1.	.3 .6 3	.3 .6 3	.0 .0 3	.3 .6 3	.0 .0 3	.0 .0 2	.2 .4 17	APRIL 20-24
2.	2.0 1.7 3	.7 1.2 3	.3 .6 3	1.7 2.9 3	.0 .0 3	.0 .0 3	.8 1.5 18	APRIL 27-30
3.	.7 1.2 3	.7 1.2 3	.3 .6 3	21.7 36.7 3	.0 .0 3	26.3 45.6 3	8.3 23.2 18	MAY 4-8
4.	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	1.3 2.3 3	.0 .0 3	.2 .9 18	MAY 11-15
5.	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.3 .6 3	.0 .0 3	.1 .2 18	MAY 18-22
6.	.3 .6 3	.0 .0 3	.0 .0 3	.7 .6 3	.3 .6 3	.0 .0 3	.2 .4 18	MAY 25-29
7.	.3 .6 3	.0 .0 3	.0 .0 3	.3 .6 3	.0 .0 3	.3 .6 3	.2 .4 18	JUNE 1-5
8.	.0 .0 3	.0 .0 3	.0 .0 3	.0 .0 3	.7 .6 3	.0 .0 3	.1 .3 18	JUNE 8-13
9.	.0 .0 3	.0 .0 3	.0 .0 3	.3 .6 3	.0 .0 3	.0 .0 3	.1 .2 18	JUNE 15-19
10.	0	0	0	.0 .0 3	.0 .0 3	0	.0 .0 6	JUNE 22-26
TOTAL	.4 .9 27	.2 .6 27	.1 .3 27	2.5 11.7 30	.3 .8 30	3.1 15.5 26	1.1 7.3 167	

1987

BREAKDOWN OF CHUM - CHUM SALMON
ACROSS - LOC - LOCATION
DOWN - DATE - DATE

LOW TIDE

M, SD, N	LOWELL 1.	GREENHOUSE 2.	NORTH 3.	CLIFF 5.	HOUSEBOAT 6.	TOTAL
1.	.0	.0	.0	2.7	.0	.5
	.0	.0	-.0	4.6	.0	2.1
	3	3	-	3	3	15
2.	32.0	.0	2.0	.3	.0	6.9
	51.1	.0	2.6	.6	.0	23.3
	3	3	3	3	3	15
3.	3.3	4.0	.0	.0	1.7	1.8
	4.9	5.3	.0	.0	1.5	3.3
	3	3	3	3	3	15
4.	.3	.0	1.3	.0	.3	.4
	.6	.0	1.2	.0	.6	.7
	3	3	3	3	3	15
5.	.7	.0	.0	.7	.0	.3
	1.2	.0	.0	.6	.0	.6
	3	3	3	3	3	15
6.	2.0	.0	.3	.0	.0	.5
	2.6	.0	.6	.0	.0	1.3
	3	3	3	3	3	15
7.	3.0			.0	.7	1.2
	2.6			.0	.6	1.9
	3	0	0	3	3	9
8.	.3	.0	.0	1.0	.0	.3
	.6	.0	.0	1.0	.0	.6
	3	3	3	3	3	15
9.	.0	.0	.0	.0	1.7	.3
	.0	.0	.0	.0	1.5	.9
	3	3	3	3	3	15
10.	2.0			.0	2.0	1.3
	2.6			.0	2.6	2.1
	3	0	0	3	3	9
TOTAL	4.4	.5	.5	.5	.6	1.4
	16.5	2.1	1.1	1.5	1.2	7.9
	30	24	24	30	30	138

HIGH TIDE

M, SD, N	LOWELL 1.	GREENHOUSE 2.	NORTH 3.	NONAME 4.	CLIFF 5.	HOUSEBOAT 6.	TOTAL	
1.	1.0	.0	.0	.0	.0	.0	.2	APRIL 20-24
	1.0	.0	.0	.0	.0	.0	.5	
	3	3	3	3	3	2	17	
2.	.0	.7	.0	37.7	.0	.3	6.4	APRIL 27-30
	.0	1.2	.0	25.5	.0	.6	16.8	
	3	3	3	3	3	3	18	
3.	5.0	3.0	8.3	21.7	.0	8.0	7.7	[illegible] 4-8
	6.9	1.7	6.0	23.5	.0	10.4	11.7	
	3	3	3	3	3	3	18	
4.	26.3	.3	1.0	10.7	1.0	.3	6.6	MA[illegible] 11-15
	45.6	.6	1.7	16.8	1.7	.6	19.4	
	3	3	3	3	3	3	18	
5.	1.3	.7	.7	13.0	1.3	.3	2.9	MAY 18-22
	2.3	1.2	.6	12.1	2.3	.6	6.4	
	3	3	3	3	3	3	18	
6.	.7	1.0	.0	10.3	.3	.0	2.1	MAY 25-29
	.6	.0	.0	14.6	.6	.0	6.3	
	3	3	3	3	3	3	18	
7.	.7	1.7	.3	7.0	.0	2.3	2.0	JUNE 1-5
	1.2	.6	.6	4.6	.0	2.1	3.0	
	3	3	3	3	3	3	18	
8.	.0	1.3	1.3	4.3	1.7	2.3	1.8	JUNE 8-13
	.0	1.5	2.3	4.2	1.2	2.5	2.4	
	3	3	3	3	3	3	18	
9.	.0	.0	.0	1.0	1.0	9.7	1.9	JUNE 15-19
	.0	.0	.0	1.7	1.7	7.0	4.4	
	3	3	3	3	3	3	18	
10.				1.3	.7		1.0	JUNE 22-26
				1.2	.6		.9	
	0	0	0	3	3	0	6	
TOTAL	3.9	1.0	1.3	10.7	.6	2.7	3.4	
	15.2	1.2	3.2	16.0	1.1	5.1	10.0	
	27	27	27	30	30	26	167	

APPENDIX B: PERCENTAGE OF SALMON FRY WITH PLANKTONIC AND EPIBENTHIC PREY

Percentage of Salmon Fry with Planktonic and Epibenthic Prey*

	Pink			Chum		
Prey Grouping	Harbor Stations	Nonharbor Stations	All Stations	Harbor Stations	Nonharbor Stations	All Stations
Ephibenthic						
Harpacticoid copepods	100	73	83	66	82	79
Amphipods	11	0	4	50	18	25
Ostracods	0	6	4	33	18	21
Gravel	0	0	8	17	5	7
Cumacea	0	0	0	0	18	14
Total % with epibenthic prey	100	80	88	100	82	86
Planktonic						
Calanoid copepods	66	66	66	83	50	57
Dipterans	22	13	17	100	100	100
Decapod zoea	0	40	25	0	18	14
Daphnia spp.	0	6	4	0	5	4
Nauplii	0	13	8	0	18	14
Fish larvae	0	0	0	0	5	4
Total % with planktonic prey	77	80	79	100	91	93
Total % with both epibenthic and planktonic prey	77	60	67	100	95	96

* No. of fish examined: Harbor stations, 9; nonharbor stations, 15; all stations, 24; harbor stations, 6; nonharbor, 22; and all stations 28.

APPENDIX C: AGE AND LENGTH DATA FOR SALMON FRY

Table C1

Mean Saltwater Ages (Inferred from Otolith Analysis) and Lengths of Juvenile Pink Salmon Reared in an Experimental Saltwater Pond, Alaska, 1987

Week	No. Days in Pond	Age, days		Length, mm		No.
		Mean	SD	Mean	SD	
5/13	6	6.0	0.5	38.1	1.7	10
5/20	13	11.9	0.4	45.7	2.7	10
5/27	20	26.5	2.3	53.6	2.0	10
6/4	28	38.1	2.7	59.7	4.2	10
6/10	34*	48.1	3.4	65.2	4.5	10
6/17	42	58.3	5.2	77.8	3.7	10
6/23	49	76.7	4.6	85.6	3.2	10

* One chum salmon was collected on this day: age = 34 days, length = 78 mm.

Table C2

Mean Saltwater Ages (Inferred from Otolith Analysis) of Juvenile Salmon Collected in Resurrection Bay, Alaska, 1987

	Lowell Point			Greenhouse			North			Noname			Cliff			Houseboat		
Week*	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
Pink																		
1													7	0.0	0.0			
2	4	0.0	0.0	4	0.0	0.0	2	0.0	0.0	5	0.0	0.0						
3	6	0.0	0.0	7	0.0	0.0	1	0.0		17	2.2	4.9				18	0.5	2.0
4							1	0.0					7	0.0	0.0			
5																		
6	8	0.3	0.7							2	0.0	0.0	2	0.0	0.0			
7	2	3.3	4.6													1	0.0	
8													2	0.0	0.0			
9										1	6.0							
10																1	7.5	
All	20	0.4	1.5	11	0.0	0.0	4	0.0	0.0	25	1.7	4.2	18	0.0	0.0	20	0.8	2.5
Chum																		
1													9	0.5	1.5			
2	10	0.9	1.7	2	5.3	0.4	5	6.2	10.7	10	2.3	3.9	1	0.0	0.0			
3	15	0.1	0.4	12	4.6	6.8	10	0.7	1.1	10	0.3	0.5				17	4.7	10.3
4							4	10.3	7.1				3	1.2	2.0			
5													6	6.4	10.0			
6	5	14.4	8.8							10	18.1	9.1	1	30.5				
7	8	23.7	12.2	6	12.8	14.9	1	39.5								8	2.5	4.9
8										2	0.0	0.0	9	27.0	17.4	7	21.1	18.3
9										1	30.5					17	36.6	10.9
10	5	23.5	12.4													9	36.1	12.7
All	43	9.1	12.7	20	7.1	10.0	20	5.9	10.5	33	7.2	10.3	29	11.0	16.0	58	20.6	19.0

* Corresponding dates: 1 = 4/20-24; 2 = 4/27-30; 3 = 5/4-8; 4 = 5/11-15; 5 = 5/18-22; 6 = 5/25-29; 7 = 6/1-5; 8 = 6/8-13; 9 = 6/15-19; 10 = 6/22-26.

Table C3

Mean Saltwater Ages (Inferred from Otolith Analysis) and Lengths of Juvenile Salmon Collected in Resurrection Bay, all Locations Combined, Alaska, 1987

Week*	Age, Days			Length, mm		
	No.	Mean	SD	No.	Mean	SD
			Pink			
4/20-24	7	0.0	0.0	7	33.0	1.6
4/27-30	15	0.0	0.0	15	32.9	1.8
5/4-8	49	0.9	3.2	49	34.2	2.2
5/11-15	8	0.0	0.0	8	34.3	0.7
5/18-22						
5/25-29	12	0.2	0.6	12	34.3	1.6
6/1-5	3	2.2	3.8	3	35.7	1.2
6/8-13	2	0.0	0.0	2	34.0	0.0
6/15-19	1	6.0	0.0	1	36.0	0.0
6/22-26	1	7.5	0.0	1	37.0	0.0
All	98	0.7	2.6	98	34.0	2.0
			Chum			
4/20-24	9	0.5	1.5	9	38.0	1.7
4/27-30	28	2.6	5.2	28	39.1	2.4
5/4-8	64	2.3	6.3	64	39.8	4.8
5/11-15	7	6.4	7.1	7	42.7	7.9
5/18-22	6	6.4	10.0	6	39.8	2.7
5/25-29	16	17.7	9.2	17	44.2	4.0
6/1-5	23	14.2	14.8	24	41.9	6.5
6/8-13	18	21.7	18.2	18	47.5	9.1
6/15-19	18	36.3	10.7	18	54.6	7.1
6/22-26	14	31.6	13.7	14	52.4	6.6
All	203*	11.8	15.5	205*	43.2	7.5

* Otoliths of two fish unusable for age analysis because of crystallization.

Table C4

Number of Growth Increments, Fork Length, and Saltwater (SW) Entry Date for Pink Salmon Sampled from Seward Pond*

Fish Number	Date Collected	Length mm	Date SW Entry	Number of Increments	Mean Age	Known Age
SP 1	5/13	37	5/7	6L	6.0	6
SP 7	5/13	41	5/7	6R, 5L	5.5	6
SP 8	5/13	40	5/7	6L	6.0	6
SP 9	5/13	39	5/7	6R, 6L	6.0	6
SP 10	5/13	38	5/7	6R	6.0	6
SP 71	5/13	36	5/7	6R	6.0	6
SP 72	5/13	36	5/7	6L, 6R	6.0	6
SP 73	5/13	38	5/7	7L, 7R	7.0	6
SP 75	5/13	37	5/7	5L, 5R	5.0	6
SP 76	5/13	39	5/7	6R, 6L	6.0	6
SP 31	5/20	47	5/7	12L, 11R	11.5	13
SP 32	5/20	44	5/7	13R, 12L	12.5	13
SP 33	5/20	48	5/7	12R, 12L	12.0	13
SP 34	5/20	47	5/7	12R	12.0	13
SP 35	5/20	40	5/7	12L, 12R	12.0	13
SP 36	5/20	47	5/7	12L, 12R	12.0	13
SP 37	5/20	44	5/7	12R, 12L	12.0	13
SP 38	5/20	49	5/7	11R	11.0	13
SP 39	5/20	47	5/7	12L, 11R	11.5	13
SP 40	5/20	44	5/7	12L, 12R	12.0	13
SP 41	5/27	54	5/7	27R, 27L	27.0	20
SP 42	5/27	53	5/7	24R, 23L	23.5	20
SP 43	5/27	55	5/7	25L, 25R	25.0	20
SP 44	5/27	54	5/7	26L, 26R	26.0	20
SP 45	5/27	50	5/7	23R, 27L	25.0	20
SP 46	5/27	51	5/7	31L	31.0	20
SP 47	5/27	54	5/7	29R, 29L	29.0	20
SP 48	5/27	56	5/7	25L, 26R	25.5	20
SP 49	5/27	56	5/7	23R, 27L	25.0	20
SP 50	5/27	53	5/7	28L, 28R	28.0	20
SP 51	6/4	59	5/7	41L, 42R	41.5	28
SP 52	6/4	58	5/7	37R, 38L	37.5	28
SP 53	6/4	61	5/7	37R	37.0	28
SP 55	6/4	54	5/7	36R	36.0	28
SP 56	6/4	61	5/7	37R, 38L	37.5	28
SP 57	6/4	52	5/7	32L, 36R	34.0	28
SP 58	6/4	62	5/7	38R, 39L	38.5	28

(Continued)

* Counts are for both left (L) and right (R) sagittae.

Table C4 (Concluded)

Fish Number	Date Collected	Length mm	Date SW Entry	Number of Increments	Mean Age	Known Age
SP 60	6/4	61	5/7	38L, 37R	37.5	28
SP 93	6/4	66	5/7	37R, 38L	37.5	28
SP 96	6/4	63	5/7	43L, 44R	43.5	28
SP 61	6/10	59	5/7	44R, 43L	43.5	34
SP 62	6/10	63	5/7	55L	55.0	34
SP 64	6/10	65	5/7	48R, 49L	48.5	34
SP 66	6/10	71	5/7	49R, 50L	49.5	34
SP 67	6/10	60	5/7	42R, 49L	45.5	34
SP 68	6/10	69	5/7	52R, 48L	50.0	34
SP 69	6/10	60	5/7	52R, 44L	48.0	34
SP 70	6/10	70	5/7	50L	50.0	34
SP 99	6/10	66	5/7	49R, 42L	45.5	34
SP 100	6/10	69	5/7	45L, 45R	45.0	34
SP 21	6/17	82	5/7	53R, 54L	53.5	42
SP 22	6/17	73	5/7	62L	62.0	42
SP 23	6/17	75	5/7	63L	63.0	42
SP 26	6/17	78	5/7	63R	63.0	42
SP 27	6/17	78	5/7	67R	67.0	42
SP 28	6/17	71	5/7	52R, 60L	56.0	42
SP 30	6/17	81	5/7	56L, 47R	51.5	42
SP 107	6/17	79	5/7	57R	57.0	42
SP 108	6/17	79	5/7	53R	53.0	42
SP 109	6/17	82	5/7	57R	57.0	42
SP 11	6/23	89	5/7	81R	81.0	49
SP 12	6/23	87	5/7	82L	82.0	49
SP 13	6/23	83	5/7	80L	80.0	49
SP 15	6/23	89	5/7	73R, 80L	76.5	49
SP 16	6/23	91	5/7	78R, 79L	78.5	49
SP 17	6/23	81	5/7	70R, 65L	67.5	49
SP 18	6/23	84	5/7	82L, 75R	78.5	49
SP 19	6/23	84	5/7	69R, 74L	71.5	49
SP 20	6/23	85	5/7	73L	73.0	49
SP 114	6/23	83	5/7	78R	78.0	49

Table C5

Ages Estimated as Counts of Daily Growth Increments and Fork Lengths of Pink and Chum Salmon from Resurrection Bay*

Location	Fish Number	Date Collected	Length mm	Age Days	Sample Date	Mean Age	Standard Deviation
			Pink salmon				
Greenhouse	G 1	4/28	33	OL	4/28	0	
	G 2	4/28	31	OL, OR	5/05	0	
	G 3	4/28	31	OR, OL			
	G 4	5/05	34	OL, OR			
	G 5	5/05	37	OR, OL			
	G 6	5/05	33	OR, OL			
	G 7	5/05	34	OR, OL			
	G 8	5/05	35	OR, OL			
	G 9	5/05	35	OL, OR			
	G 10	5/05	32	OL, OR			
	G 11	5/05	30(1)	OR			
Noname	NN 1	5/05	43	10R, 10L	4/28	0	
	NN 2	5/05	39	6R, 6L	5/05	2.17	4.93
	NN 3	5/05	37	3L, 3R	5/28	0	
	NN 4	5/05	34	OL, OR			
	NN 5	5/05	32	OL, OR			
	NN 6	5/28	35	OL, OR			
	NN 7	5/28	35	OL, OR			
	NN 8	4/28	35	OL, OR			
	NN 9	4/28	34	OL, OR			
	NN 10	4/28	34	OL, OR			
	NN 11	6/15	36	6L, 6R			
	NN 12	5/05	35	OL, OR			
	NN 13	5/05	35	OL, OR			
	NN 14	5/05	40	18L, 18R			
	NN 15	5/05	34	OL, OR			
	NN 16	5/05	33	OL, OR			
	NN 17	5/05	34	OL, OR			
	NN 18	5/05	35	OL, OR			
	NN 19	5/05	35	OL, OR			
	NN 20	5/05	32	OL, OR			
	NN 21	4/28	34	OL, OR			
	NN 22	4/28	34	OL, OR			

(Continued)

* Counts are for both left (L) and right (R) sagittae. When different, counts for left and right sagittae were averaged in the calculations for mean age at each date.

(Sheet 1 of 8)

Table C5 (Continued)

Location	Fish Number	Date Collected	Length mm	Age Days	Sample Date	Mean Age	Standard Deviation
Noname	NN 23	5/05	34	OL, OR			
	NN 24	5/05	32	OL, OR			
	NN 25	5/05	33	OL, OR			
Houseboat	H 1	5/05	34	OR	5/05	0.47	2.00
	H 2	5/05	32	OR, OL	6/03	3.75	5.30
	H 3	5/05	33(1)	OL			
	H 4	6/03	37	OL, OR			
	H 5	5/05	32	OL			
	H 6	5/05	34	OL, OR			
	H 7	5/05	33	OR			
	H 8	5/05	32	OL, OR			
	H 9	5/05	34	OL, OR			
	H 10	5/05	34	OL, OR			
	H 11	6/23	37	8L, 7R			
	H 12	5/05	37	OR, OL			
	H 13	5/05	34	8L, 9R			
	H 14	5/05	33	OL, OR			
	H 15	5/05	33	OL, OR			
	H 16	5/05	34	OR, OL			
	H 17	5/05	34	OR, OL			
	H 18	5/05	35	OR, OL			
	H 19	5/05	32	OR, OL			
	H 20	5/05	33	OR, OL			
Cliff	C 1	4/20	33	OR, OL	4/20	0	
	C 2	4/20	33	OR	5/11	0	
	C 3	4/20	31	OL, OR	5/13	0	
	C 4	5/11	34 (1)	OR	5/27	0	
	C 5	5/11	33	OL, OR	6/08	0	
	C 6	5/11	35(1)	OR	6/09	0	
	C 7	5/13	34	OL, OR			
	C 8	5/27	35	OL, OR			
	C 9	5/27	36	OL, OR			
	C 10	6/09	34	OL, OR			
	C 11	5/11	35	OL, OR			
	C 12	5/11	34	OR			
	C 13	5/11	34	OL, OR			
	C 14	4/20	32	OR, OL			
	C 15	4/20	36	OL, OR			
	C 16	4/20	34	OL, OR			
	C 17	4/20	32	OL, OR			
	C 18	6/08	34	OR			

(Continued)

(Sheet 2 of 8)

Table C5 (Continued)

Location	Fish Number	Date Collected	Length mm	Age Days	Sample Date	Mean Age	Standard Deviation
North	N 1	4/27	30	0	4/27	0	
	N 2	4/28	32	0	4/28	0	
	N 3	5/06	36	OL, OR	5/06	0	
	N 4	5/12	35	0	5/12	0	
Lowell Point	L 1	4/28	31	OL	4/27	0	
	L 2	4/27	31	OL, OR	4/28	0	
	L 3	4/27	36	OL, OR	5/04	0	
	L 4	5/04	34(1)	OR	5/05	0	
	L 5	5/04	35	OL, OR	5/05	0	
	L 6	5/04	33	OL, OR	5/27	1	1.41
	L 7	5/04	33	OL, OR	6/03	3.25	4.59
	L 8	5/04	35	OL, OR			
	L 9	5/05	34	OL, OR			
	L 10	4/27	32	OL, OR			
	L 11	6/03	35	OL, OR			
	L 12	6/03	35	8L, 5R			
	L 13	5/27	36	OL, OR			
	L 14	5/27	36	2L			
	L 15	4/27	35	OR, OL			
	L 16	4/27	31	OL, OR			
	L 17	4/27	34	OL, OR			
	L 18	4/28	34	OL, OR			
	L 19	4/28	32	OR, OL			
	L 20	4/28	33	OR, OL			
			Chum salmon				
	CL 1	5/05	41	OR, 1L	4/28	0.80	1.62
	CL 2	5/05	36	OL	5/04	0	
	CL 3	5/05	37	OL, OR	5/05	1.05	2.81
	CL 4	5/05	39	1L, 1R	5/27	14.40	8.76
	CL 5	5/05	40	OR, OL	6/03	22.56	11.96
	CL 6	4/28	41	OR	6/23	23.50	12.44
	CL 7	4/28	39	OR, OL			
	CL 8	4/28	38	OL, OR			
	CL 9	4/28	39	2L, 2R			
	CL 10	4/28	38	OL, 2R			
	CL 11	6/23	51	21L, 21R			
	CL 12	6/23	44	9L, 10R			
	CL 13	6/23	60	44L, 42R			
	CL 14	6/23	46	18L			
	CL 15	6/23	53	26L			

(Continued)

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Table C5 (Continued)

Location	Fish Number	Date Collected	Length mm	Age Days	Sample Date	Mean Age	Standard Deviation
Lowell	CL 16	5/27	45	23R, 23L			
Point	CL 17	5/27	43	6R, 6L			
	CL 18	5/27	43	23L			
	CL 19	5/27	40	5R, 5L			
	CL 20	6/03	41	12R, 12L			
	CL 21	6/03	55	48R, 48L			
	CL 22	6/03	41	17L, 18R			
	CL 23	6/03	43	24L, 23R			
	CL 24	6/03	54	25R, 26L			
	CL 25	4/28	39	0L, 0R			
	CL 26	4/28	39	0L, 0R			
	CL 27	4/28	36	5L, 5R			
	CL 28	4/28	37	0L, 0R			
	CL 29	4/28	39	0L, 0R			
	CL 30	5/04	40	0L, 0R			
	CL 31	5/04	39	0L, 0R			
	CL 32	5/04	36	0L, 0R			
	CL 33	5/04	38	0L, 0R			
	CL 34	5/04	36	0L			
	CL 35	5/05	38	0L, 0R			
	CL 36	5/05	37	0R, 0L			
	CL 37	5/05	38	0R, 0L			
	CL 38	5/05	40	0R, 0L			
	CL 39	5/05	37	0L, 0R			
	CL 40	5/27	43	15L, 15R			
	CL 41	6/03	50	35R, 33L			
	CL 42	6/03	40	17R, 16L			
	CL 43	6/03	48	Crystal			
	CL 44	6/03	42	13R			
Noname	CNN 1	4/28	39	0L, 0R			
	CNN 2	4/28	39	0L, 0R	4/28	2.30	3.86
	CNN 3	4/28	40	5L, 5R	5/05	0.25	0.42
	CNN 4	4/28	39	0L, 0R	5/28	17.95	9.00
	CNN 5	4/28	43	9L, 9R	6/15	10.17	17.61
	CNN 6	4/28	36	0L, 0R			
	CNN 7	4/28	37	0L, 0R			
	CNN 8	4/28	39	0L, 0R			
	CNN 9	4/28	38	0L, 0R			
	CNN 10	4/28	41	9L, 9R			
	CNN 11	5/28	45	21R, 21L			
	CNN 12	5/28	48	24R, 23L			
	CNN 13	5/28	39	3L, 3R			
	CNN 14	5/28	44	23R, 24L			

(Continued)

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Table C5 (Continued)

Location	Fish Number	Date Collected	Length mm	Age Days	Sample Date	Mean Age	Standard Deviation
Noname	CNN 15	5/28	49	23L, 24R			
	CNN 16	5/28	44	16R, 16L			
	CNN 17	5/28	44	23R, 24L			
	CNN 18	5/28	42	22L, 22R			
	CNN 19	5/28	46	24L, 25R			
	CNN 20	5/28	38	OR, OL			
	CNN 21	6/15	46	31L, 30R			
	CNN 22	6/15	40	OL, OR			
	CNN 23	6/15	39	OL, OR			
	CNN 24	5/05	40	OR, 1L			
	CNN 25	5/05	40	1L, 1R			
	CNN 26	5/05	40	OL, OR			
	CNN 27	5/05	31	OL, OR			
	CNN 28	5/05	36	OL, OR			
	CNN 29	5/05	35	1L, 1R			
	CNN 30	5/05	40	OR, OL			
	CNN 31	5/05	39	OL, OR			
	CNN 32	5/05	41	OR, OL			
	CNN 33	5/05	40	OR, OL			
Houseboat	CH 1	5/04	32	OL, OR	5/04	0.29	0.76
	CH 2	5/04	40	2R, 2L	5/05	7.80	12.79
	CH 3	5/04	39	OR, OL	6/03	2.86	5.18
	CH 4	5/04	36	OR, OL	6/09	21.14	18.34
	CH 5	5/04	36	OR, OL	6/15	36.59	10.88
	CH 6	5/04	35	OR, OL	6/23	36.06	12.74
	CH 7	5/04	36	OL			
	CH 8	6/15	60	40L, 41R			
	CH 9	6/15	55	36R, 35L			
	CH 10	6/15	52	30R, 30L			
	CH 11	6/15	35	2L, 2R			
	CH 12	6/15	54	34L, 33R			
	CH 13	6/15	53	33R, 33L			
	CH 14	6/15	62	43R, 43L			
	CH 15	6/15	59	47L, 43R			
	CH 16	6/03	42	13R			
	CH 17	6/03	40	7R, 7L			
	CH 18	6/03	40	OL, OR			
	CH 19	6/03	37	OL, OR			
	CH 20	6/03	38	OL, OR			
	CH 21	6/03	37	OL, OR			
	CH 22	6/03	40	OL, OR			
	CH 23	6/23	50	29R, 29L			

(Continued)

(Sheet 5 of 8)

Table C5 (Continued)

Location	Fish Number	Date Collected	Length mm	Age Days	Sample Date	Mean Age	Standard Deviation
Houseboat	CH 24	6/23	55	50L, 51R			
	CH 25	6/23	60	48L, 48R			
	CH 26	6/23	63	48R, 49L			
	CH 27	6/23	46	24R, 23L			
	CH 28	6/23	55	36R, 36L			
	CH 29	6/23	41	13L, 12R			
	CH 30	6/23	57	41R, 42L			
	CH 31	6/23	53	35R, 35L			
	CH 32	6/15	57	42R, 43L			
	CH 33	6/15	62	51L, 49R			
	CH 34	6/15	52	39R, 39L			
	CH 35	6/15	56	43R, 44I			
	CH 36	6/15	52	37L, 38R			
	CH 37	6/09	52	37L, 37R			
	CH 38	6/09	54	39R, 36L			
	CH 39	6/09	51	33R, 34L			
	CH 40	6/09	39	OR, OL			
	CH 41	6/09	37	5L, 5R			
	CH 42	6/09	39	OL, OR			
	CH 43	6/09	49	35L, 35R			
	CH 44	6/05	37	OL, OR			
	CH 45	5/05	38	4L, 4R			
	CH 46	5/05	38	1L, 1R			
	CH 47	5/05	36	OL, OR			
	CH 48	5/05	39	3R, 3L			
	CH 49	5/05	37	OL, OR			
	CH 50	5/05	51	38R, 38L			
	CH 51	5/05	37	OL, OR			
	CH 52	5/05	48	23L, 23R			
	CH 53	5/05	38	9R, 9L			
	CH 54	5/05	36	OL, OR			
	CH 55	6/15	61	43R, 43L			
	CH 56	6/15	45	25L, 25R			
	CH 57	6/15	60	35R			
	CH 58	6/15	61	44L, 44R			
Greenhouse	OG 1	4/28	39	5R, 5L	4/28	5.25	0.35
	OG 2	4/28	41	5R, 6L	5/05	4.58	6.77
	OG 3	5/05	44	19R, 18L	6/03	12.75	14.91
	OG 4	5/05	43	17L, 17R			
	OG 5	5/05	38	OR, OL			
	OG 6	5/05	42	10L, 10R			
	OG 7	5/05	40	OL, 1R			

(Continued)

(Sheet 6 of 8)

Table C5 (Continued)

Location	Fish Number	Date Collected	Length mm	Age Days	Sample Date	Mean Age	Standard Deviation
	OG 8	5/05	41	2L			
	OG 9	5/05	41	4L, 4R			
	OG 10	5/05	37	OL, OR			
	OG 11	5/05	38	OL, OR			
	OG 12	5/05	39	1L, 1R			
	OG 13	6/03	44	21R, 22L			
	OG 14	6/03	29	OL, OR			
	OG 15	6/03	51	35R, 35L			
	OG 16	5/05	38	OL, OR			
	OG 17	5/05	40	2R, 2L			
	OG 18	6/03	40	20R, 20L			
	OG 19	6/03	30	OL, OR			
	OG 20	6/03	39	OR, OL			
North	CN 1	4/27	40	1L, 1R	4/27	6.20	10.70
	CN 2	4/27	40	OR	5/06	0.65	1.11
	CN 3	4/27	47	24R, 26L	5/12	10.25	7.14
	CN 4	4/27	40	5R, 5L	6/03	39.50	
	CN 5	4/27	39	OR, OL			
	CN 6	5/06	39	OR, OL			
	CN 7	5/06	43	3R, 4L			
	CN 8	5/06	40	OL, OR			
	CN 9	5/06	41	1L, 1R			
	CN 10	5/06	40	1L, 1R			
	CN 11	5/06	39	1L, 1R			
	CN 12	5/06	42	OL, OR			
	CN 13	5/06	40	OL, OR			
	CN 14	5/06	39	OL, OR			
	CN 15	5/06	37	OL, OR			
	CN 16	5/12	40	2L, 2R			
	CN 17	5/12	42	8R, 8L			
	CN 18	5/12	42	12L, 12R			
	CN 19	5/12	60	19L, 19R			
	CN 20	5/26	44	Crystal			
	CN 21	6/03	47	36R, 43L			
Cliff	CC 1	4/20	38	OL, OR	4/20	0.50	1.50
	CC 2	4/20	38	OL, OR	4/27	0	
	CC 3	4/20	39	OL, OR	5/18	0	
	CC 4	4/20	37	OL, OR	5/19	19.25	2.47
	CC 5	4/20	39	OL, OR	5/27	30.50	
	CC 6	4/27	34	OL, OR	6/08	40.75	7.63
	CC 7	5/18	40	OL, OR	6/09	16.00	14.93

(Continued)

(Sheet 7 of 8)

Table C5 (Concluded)

Location	Fish Number	Date Collected	Length mm	Age Days	Sample Date	Mean Age	Standard Deviation
	CC 8	5/18	38	OL, OR			
	CC 9	5/18	38	OL, OR			
	CC 10	5/18	37	OL, OR			
	CC 11	5/27	55	30L, 31R			
	CC 12	6/09	43	23R, 23L			
	CC 13	6/09	39	OL, OR			
	CC 14	6/09	54	31R, 32L			
	CC 15	6/09	39	OL, OR			
	CC 16	6/08	61	42R, 43L			
	CC 17	6/08	49	30L, 29R			
	CC 18	6/08	61	46R, 45L			
	CC 19	6/08	66	45L, 46R			
	CC 20	5/11	36	OL, OR			
	CC 21	5/11	41	4L, 3R			
	CC 22	4/20	37	OL, OR			
	CC 23	4/20	41	5L, 4R			
	CC 24	4/20	38	OL, OR			
	CC 25	4/20	35	OL, OR			
	CC 26	5/11	38	OL, OR			
	CC 27	5/19	44	18R, 12L			
	CC 28	5/19	42	21R, 21L			
	CC 29	6/09	43	26L, 25R			

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APPENDIX D: WATER QUALITY DATA

Table D1

Water Quality Data Collected in Resurrection Bay by Station, 1986

				Hydrolab					Current Meter			Transmissometer			
Location	Tide	Inshore—Offshore	Date	Depth m	Temperature °C	pH	Dissolved Oxygen mg/L	Conductivity mmho	Depth m	Speed knots	Direction degrees	Depth m	Transmission %	Nephelometer %	Nephelometer Scale
Lowell Pt.	Low	In	—	—	—	—	—	—	—	—	—	—	—	—	
		Off	4/18	17.5	3.6	8.2	11.6	47.6	—	—	—	22.5	0.80	0.010	100
				8.5	3.7	8.3	12.3	.5	—	—	—	11.0	0.65	0.001	100
				0	3.8	8.3	12.4	46.9	—	—	—	0	0.92	0.005	100
	High	In	4/21	3.8	4.0	8.2	13.1	47.6	15.8	0.40	255	14.0	90.0	0	100
				—	—	—	—	—	7.9	0.25	230	7.2	83.0	0	100
				0	4.3	0.2	12.5	46.7	0	0.20	255	0	82.0	0	100
		Off	4/21	25.6	3.5	7.9	10.4	47.8	2.1	0.90	75	5.0	75.0	0.03	100
				13.0	3.6	7.9	10.4	47.7	1.1	0.40	295	2.5	80.0	0.20	100
				0	4.5	8.2	11.8	47.4	0	0.25	315	0	63.0	0.20	100
Greenhouse	Low	In	4/23	2.5	5.0	8.1	11.4	46.5	—	—	-	1.5	82.0	0.12	1
				0	7.0	8.2	11.4	33.9	0	0.70	300	0	65.0	0.40	1
		Off	4/23	15.7	3.9	8.1	12.4	47.9	12.2	0.40	210	13.5	50.0	0.005	100
				7.9	4.2	8.2	12.6	47.7	6.1	0.50	75	7.0	75.0	0.05	1
				0	4.8	8.1	11.8	46.5	0	0.13	30	0	88.0	0.20	1
	High	In	4/22	3.7	3.9	8.1	11.8	47.7	0.9	0.20	150	3	65.0	0.10	10
				—	—	—	—	—	—	—	—	1.5	65.0	0.15	10
				0	3.9	8.1	11.6	47.8	0	0.30	200	0	65.0	0.35	10
		Off	4/22	13.6	3.6	8.1	11.2	47.8	10.4	0.30	75	12	68.0	0	100
				6.5	3.8	8.1	11.5	47.7	5.2	0.50	250	6	68.0	0.15	1
				0	3.8	8.2	11.6	47.8	0	0.30	212	0	69.0	0.30	10
North	Low	In	4/23	4.5	5.1	8.1	12.7	47.5	1.8	0.43	225	3.0	74.0	0.10	1
				0	5.3	8.1	11.7	45.8	0	0.40	97	0	82.0	0.08	1
		Off	4/23	15.5	3.9	8.1	12.5	47.9	13.4	0.20	90	14.5	57.0	0	100
				8.1	4.7	8.1	12.4	47.7	6.1	0.80	345	7.0	72.0	0	100
				0	5.1	8.1	11.4	45.7	0	0.40	50	0	85.0	0.35	1
	High	In	4/22	4.0	3.6	8.0	11.4	47.8	1.2	0.20	150	3.0	65.0	0.10	10
				—	—	—	—	—	—	—	—	1.5	70.0	0.18	10
				0	3.8	8.1	11.3	46.5	0	0.50	180	0	70.0	0.33	10

(Continued)

Table D1 (Concluded)

Location	Tide	Inshore—Offshore	Date	Hydrolab Depth m	Hydrolab Temperature °C	Hydrolab pH	Hydrolab Dissolved Oxygen mg/ℓ	Hydrolab Conductivity μmho	Current Meter Depth m	Current Meter Speed knots	Current Meter Direction degrees	Transmissometer Depth m	Transmissometer Transmission %	Transmissometer Nephelometer %	Transmissometer Nephelometer Scale
North (Cont.)		Off	4/22	15.1	3.6	8.0	11.3	47.8	12.2	0.20	210	15.0	35.0	0	100
				7.5	3.6	8.0	11.1	47.8	6.1	0.10	120	7.5	68.0	0.4	1
				0	4.0	8.1	11.4	43.4	0	0.30	190	0	70.0	0.5	10
Noname	Low	In	4/23	3.5	4.8	8.1	13.2	47.6	1.0	0.30	110	2	91.0	0.02	1
				0	4.8	8.1	12.3	47.6	0	0.30	110	0	95.0	0	100
		Off	4/23	17.4	3.8	8.0	11.7	47.8	13.4	0.17	217	15.0	69.0	0	100
				8.5	4.7	8.1	12.3	47.6	6.7	0.20	255	7.5	95.0	0	100
				0	4.8	8.1	12.1	47.4	0	0.25	40	0	98.0	0.08	1
	High	In	4/23	4.1	4.2	8.2	12.3	47.6	1.5	0.25	45	3	70.0	0.10	10
				0	4.6	8.2	12.2	47.4	0	0.40	65	0	94.0	0.30	10
		Off	4/23	16.3	3.7	8.2	11.9	47.8	14.0	0	225	16.0	68.0	0	100
				8.1	3.9	8.2	12.2	47.8	7.0	0.5	225	8.0	72.0	0.1	100
				0	4.5	8.2	12.1	47.3	0	0.4	30	0	90.0	0.1	10
Cliff	Low	In	5/7	4.0	6.2	8.1	10.6	46.8	1.7	0.5	120	3.0	80.0	24.0	100
				0	6.5	8.1	10.2	46.2	0	0.3	110	0	50.0	7.0	10
		Off –	See Noname/Low Tide/Offshore												
	High	In	4/22	4.1	4.4	8.2	12.6	47.7	1.2	0.23	60	3.0	64.0	0.35	10
				0	4.7	8.3	12.3	47.7	0	0.37	75	0	95.0	0.22	10
		Off –	See Noname/High Tide/Offshore												
Houseboat	Low	In	5/7	3.4	6.3	8.1	10.1	46.7	—	—	—	2.0	18.0	48.0	1
				0	6.4	8.1	9.6	46.5	0	0.33	155	0	8.0	88.0	1
		Off	5/7	16.5	4.3	8.0	10.8	47.8	12.2	0.17	140	12.5	66.0	0	100
				8.3	5.9	8.1	10.6	47.3	6.1	0.23	220	6.5	94.0	0	100
				0	6.4	8.0	9.9	46.3	0	0.97	180	0	19.0	16.0	10
	High	In	4/23	3.0	4.5	8.1	13.0	47.6	1.0	0.80	30	1.5	84.0	0.10	10
				0	4.7	8.1	12.5	47.5	0	0.80	30	0	85.0	0.50	10
		Off	4/23	17.0	3.9	8.1	13.2	47.9	12.8	0.17	270	13.5	0.71	0	10
				8.8	4.1	8.1	12.6	47.7	6.4	0.20	338	7.0	0.76	0.15	10
				0	5.0	8.1	11.9	47.1	0	0.25	333	0	0.96	0.22	10

Table D2

Depth, Temperature (temp.), pH, Dissolved Oxygen (D.O.), and Conductivity (cond.) in Micromhos (µmho)

from Inshore and Offshore Locations by Tide, Station, Date, and Depth

	Inshore										Offshore														
	Bottom					Surface					Bottom					Mid					Surface				
Location/ Date	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho
Noname																									
4/22	1.6	4.8	7.6	12.2	46.0	0.7	4.8	7.6	11.9	44.0															
4/29	0.6	7.3	7.9	12.6	47.0	0.1	7.6	7.9	13.3	44.7															
5/7	0.7	7.8	8.0	12.5	45.4	0.1	5.5	7.9	13.8	35.5															
5/13	0.8	7.5	7.7	14.0	9.5	0.2	7.4	7.7	12.8	8.2															
5/19	1.8	7.9	7.7	11.0	42.2	0.7	5.7	7.8	12.3	25.7															
5/28	1.0	7.2	7.5	12.4	6.3	0.4	7.4	7.3	11.8	0.6															
6/3	—	—	—	—	—	0.5	4.7	7.2	12.5	0.1															
6/9	1.2	9.2	7.8	9.6	30.6	0.3	5.2	7.4	12.2	2.7															
6/17	1.0	9.0	7.7	10.7	26.0	0.2	5.2	7.2	13.6	2.7															
6/23	—	—	—	—	—	0.3	5.0	7.6	14.3	15.7															
Cliff																									
4/22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4/29	1.1	6.6	7.9	18.3	45.9	0.2	5.7	7.9	23.2	36.7	10.4	4.6	7.7	25.7	50.8	5.0	4.6	7.7	23.3	50.7	0.3	5.3	7.8	29.5	48.9
5/7	1.0	7.8	8.1	12.5	46.1	0.1	7.3	8.1	13.1	42.0	24.5	4.5	7.8	11.3	50.6	12.2	5.3	8.0	13.6	50.2	0.1	6.6	8.1	13.5	37.6
5/13	1.4	7.6	7.7	11.8	45.4	0.3	7.9	7.7	11.7	42.6	7.6	6.8	7.7	12.2	49.4	3.6	7.2	7.7	11.9	48.2	0.3	7.3	7.7	12.0	47.8
5/19	1.6	7.9	7.8	10.5	42.2	0.6	6.7	7.8	11.9	32.6	20.7	6.3	7.8	11.0	50.2	10.4	7.1	7.8	11.1	49.8	0.6	4.9	7.5	13.7	7.3
5/28	1.0	6.9	7.7	12.3	9.4	0.4	7.3	7.7	11.7	6.6	13.7	7.6	7.7	10.3	49.2	6.8	7.8	7.8	10.5	48.9	0.3	8.1	7.7	12.2	11.7
6/3	2.0	10.5	7.8	10.1	37.3	0.4	8.7	7.6	12.1	1.0	16.0	7.4	7.7	10.8	49.7	8.0	8.0	7.8	10.9	48.9	0.4	10.9	7.7	11.1	15.7
6/9	1.2	9.7	7.9	9.2	33.8	0.3	7.6	7.4	11.5	6.1	12.8	8.0	7.8	10.3	49.1	6.4	8.8	7.8	10.2	47.9	0.3	6.7	7.6	12.4	1.6
6/17	1.6	9.9	7.8	10.0	37.5	0.2	6.8	7.6	12.7	3.5	15.6	7.7	7.8	10.5	49.3	7.8	9.9	7.8	9.4	44.0	0.2	7.0	7.7	12.5	5.9
6/23	2.2	8.5	7.8	10.6	45.0	0.2	6.8	7.8	12.8	13.5	15.0	7.9	7.8	10.3	49.3	7.5	8.2	7.8	10.5	48.3	0.2	6.9	7.3	13.8	0.7
Houseboat																									
5/7	0.6	7.7	8.0	12.2	45.3	0.1	7.4	8.0	12.5	44.0	22.5	4.9	7.6	12.0	50.3	11.1	5.7	7.9	13.7	49.9	0.1	7.5	8.0	12.7	45.5
5/13	—	—	—	—	—	0.4	9.0	7.8	12.5	47.9	19.3	5.1	7.6	10.8	50.5	8.0	6.7	7.7	12.1	49.3	0.3	7.6	7.7	11.8	46.1
6/9	1.7	10.0	7.8	6.9	36.8	0.3	8.1	7.8	11.0	14.8	8.5	8.6	7.9	10.4	48.3	4.2	9.5	7.9	9.8	45.8	0.3	8.2	7.8	11.4	15.2
Lovell Point																									
5/7	0.8	7.3	7.9	12.9	45.5	0.1	7.9	7.9	12.1	31.1	20.1	4.7	7.6	10.4	50.5	9.9	5.4	7.9	14.1	50.0	0.1	6.9	7.9	12.6	36.5
5/13	1.5	7.5	7.7	12.0	45.2	0.4	6.1	7.7	11.8	40.3	20.1	4.8	7.5	10.1	50.8	10.1	4.9	7.5	10.7	50.7	0.3	7.7	7.7	11.9	43.3
6/9	1.0	8.8	7.9	10.1	25.1	0.4	8.0	7.8	11.4	8.7	20.6	8.0	7.8	10.4	49.3	10.2	8.5	7.8	10.3	48.5	0.4	7.8	7.7	11.6	9.2
Green-house																									
4/22	1.8	4.9	7.8	12.5	46.7	0.8	4.5	7.7	11.8	43.9	26.6	4.5	7.7	11.0	47.8	13.3	4.6	7.7	11.1	47.7	0.7	3.9	7.7	13.0	24.0
5/7	0.9	7.7	8.0	13.0	46.4	0.1	5.0	8.0	14.8	13.5	23.6	4.9	7.8	12.4	50.6	11.8	6.0	7.9	15.9	49.4	0.1	5.4	8.0	13.4	30.0
5/13	—	—	—	—	—	0.6	9.3	7.7	12.5	10.4	24.2	4.9	7.5	11.0	50.2	11.1	6.1	7.7	12.5	49.7	0.6	7.9	7.7	12.1	46.6
6/9	1.8	9.9	7.8	9.3	36.2	0.3	7.3	7.6	11.8	4.3	13.6	8.2	7.8	10.3	48.9	6.7	8.7	7.9	10.3	48.3	0.3	8.5	7.8	11.3	11.0
North																									
4/29											—	—	—	—	—	—	—	—	—	—	0.5	4.9	7.7	20.9	48.9
5/6	—	—	—	—	—	0.1	3.3	7.7	17.1	2.3	3.6	5.3	7.9	15.0	50.2	1.7	5.9	7.9	15.6	49.6	0.1	5.3	8.0	18.8	33.5
5/13	—	—	—	—	—	0.5	6.8	7.7	12.2	5.5	17.3	5.3	7.5	11.3	50.5	8.6	7.3	7.6	11.9	48.6	0.5	7.7	7.6	11.5	47.5
6/9	0.8	6.9	7.7	11.2	11.1	0.3	6.2	7.7	11.5	2.7	13.2	8.3	7.8	10.3	48.7	6.6	8.6	7.8	10.2	48.3	0.3	5.7	7.6	12.2	1.2

(Continued)

Table D2 (Concluded)

Location/ Date	Inshore										Offshore														
	Bottom					Surface					Bottom					Mid					Surface				
	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho	Depth m	Temp. °C	pH	D.O. mg/l	Cond. µmho
Lowell Point																									
4/22	1.4	4.7	7.8	12.8	46.8	0.7	4.4	7.7	12.5	29.3	18.2	4.4	7.7	11.1	47.9	9.1	4.5	7.7	11.4	47.6	0.7	4.4	7.8	12.8	35.6
4/28	1.2	6.4	7.8	12.5	47.5	0.1	6.5	7.8	12.5	46.9	18.4	4.6	7.7	10.7	50.7	9.3	4.6	7.7	11.0	50.6	0.2	6.3	7.8	12.3	46.8
5/6	0.9	8.6	7.7	11.7	43.9	0.1	8.6	7.7	12.4	44.0	10.0	4.7	7.5	10.6	50.4	5.0	5.0	7.6	12.9	50.5	0.2	8.1	7.8	12.5	43.9
5/13	1.0	6.7	7.7	11.9	46.6	0.4	6.8	7.7	12.3	44.5	24.1	4.8	7.6	10.2	50.6	12.1	5.1	7.7	11.7	50.2	0.5	6.7	7.8	12.4	45.3
6/9	--	--	--	--	--	0.2	9.7	7.8	10.7	17.4	23.7	7.9	7.8	10.4	49.4	11.6	8.4	7.8	10.3	48.5	0.3	9.7	7.6	10.4	19.8
Green-house																									
4/21	1.3	5.8	7.7	12.5	44.0	0.7	4.4	7.7	12.3	33.5	6.8	4.7	7.7	11.4	47.5	3.4	5.2	7.7	11.3	45.3	0.7	5.3	7.7	11.4	39.6
4/28	1.1	6.9	7.8	12.1	47.5	0.3	6.9	7.8	12.5	36.1	16.6	4.5	7.6	10.5	50.7	8.3	4.6	7.7	11.2	50.5	0.3	6.7	7.8	12.3	41.6
5/6	--	--	--	--	--	0.1	6.5	8.0	14.1	18.4	24.4	4.7	7.6	10.7	50.6	12.2	4.8	7.7	11.3	50.3	0.1	7.2	8.0	14.5	45.2
5/13	--	--	--	--	--	0.4	7.3	7.7	12.0	47.0	24.0	4.8	7.6	10.3	50.7	12.0	5.4	7.7	11.5	50.3	0.4	7.1	7.7	11.9	47.4
6/9	1.2	8.6	7.7	10.9	7.1	0.3	8.5	7.7	11.5	6.3	10.0	8.3	7.8	10.3	48.7	5.0	8.8	7.8	9.9	47.6	0.3	8.7	7.7	12.1	6.9
North																									
4/22	1.6	5.3	7.8	12.7	46.9	0.7	5.3	7.8	12.7	22.5	17.9	4.5	7.6	10.8	48.0	8.9	4.7	7.7	11.1	47.9	0.8	5.1	7.7	12.1	38.0
4/28	0.9	6.7	7.8	12.2	48.0	0.3	7.4	7.8	13.0	36.0	23.1	4.6	7.6	10.3	50.7	12.5	4.5	7.6	10.3	50.7	0.3	6.9	7.9	12.8	26.0
5/6	0.9	7.4	8.0	14.2	46.5	0.1	7.0	8.0	14.8	25.1	19.9	4.6	7.5	10.5	50.7	10.0	4.7	7.5	10.8	50.7	0.1	7.3	8.0	14.3	39.7
5/13	--	--	--	--	--	0.4	7.0	7.8	11.8	45.0	14.4	5.3	7.7	11.5	50.5	7.2	6.3	7.8	12.0	49.3	0.4	5.9	7.0	12.7	34.4
6/9	1.3	7.3	7.9	11.2	4.2	0.3	6.5	7.7	11.8	0.4	8.3	8.6	7.8	10.2	48.3	4.2	9.4	7.8	9.8	45.7	0.3	7.4	7.6	11.9	1.1
Cliff																									
4/22	--	--	--	--	--	0.9	6.2	7.9	13.8	42.6	10.8	4.7	7.7	11.1	47.9	5.3	4.8	7.7	11.3	47.7	0.7	5.0	7.8	13.0	25.8
4/28	0.7	7.0	7.8	12.3	48.7	0.3	7.3	7.9	14.1	25.6	14.1	4.6	7.6	10.6	50.7	7.0	4.7	7.7	11.2	50.5	0.3	7.2	7.8	13.3	42.0
5/6	0.6	9.1	7.9	14.4	46.2	0.1	8.7	7.9	12.7	30.5	14.6	4.7	7.5	10.8	50.7	7.4	6.8	7.9	14.3	48.6	0.1	8.9	7.9	13.0	39.3
5/13	--	--	--	--	--	0.5	6.8	7.8	12.1	48.5	24.0	5.0	7.7	10.3	50.7	12.0	6.3	7.8	12.1	49.7	0.4	6.7	7.8	11.9	46.2
5/19	--	--	--	--	--	0.6	8.5	7.9	11.2	34.3	23.4	6.0	7.8	10.6	50.1	11.5	7.0	7.8	10.8	49.9	0.7	6.9	7.9	11.5	24.4
5/27	--	--	--	--	--	0.5	6.5	7.8	11.0	24.3	18.7	6.4	7.8	10.5	50.2	9.3	7.1	7.8	10.8	49.9	0.4	5.8	7.9	12.1	17.1
6/4	--	--	--	--	--	0.1	11.6	8.0	10.6	33.7	20.7	5.9	7.8	9.9	50.0	10.3	7.8	7.9	10.6	49.2	0.1	10.8	8.0	10.7	32.1
6/9	1.8	9.9	7.8	9.1	36.1	0.3	8.5	7.6	11.6	3.6	11.2	8.3	7.8	10.2	48.7	5.6	9.2	7.8	9.8	47.1	0.2	8.4	7.5	11.6	3.4
6/16	--	--	--	--	--	0.7	6.4	7.3	12.3	7.4	16.9	7.3	7.7	10.4	49.7	8.2	10.1	7.8	9.8	43.4	0.3	5.4	7.6	13.4	2.0
6/23	--	--	--	--	--	0.4	3.4	7.3	14.0	0.9	15.2	7.8	7.7	10.2	49.3	7.6	8.2	7.8	10.6	47.7	0.3	4.3	7.5	14.0	1.4
Houseboat																									
4/22	1.3	4.9	7.8	12.2	47.4	0.7	4.9	7.7	12.2	47.1	13.0	4.7	7.7	11.5	47.8	6.4	4.7	7.7	11.4	47.6	0.7	5.0	7.7	12.7	43.4
4/28	0.7	6.6	7.4	12.8	48.4	0.3	6.7	7.9	13.3	47.2	17.7	4.6	7.7	10.4	50.9	9.0	4.6	7.7	10.8	50.7	0.3	6.6	7.8	12.3	47.2
5/6	0.9	6.9	7.8	14.0	48.3	0.1	7.2	7.8	14.1	46.8	22.1	4.7	7.5	10.4	50.8	11.6	4.7	7.5	10.6	50.6	0.2	7.1	7.8	13.9	48.2
5/13	1.0	6.7	7.8	11.5	46.4	0.4	5.6	7.1	10.9	33.4	24.0	4.9	7.7	10.3	50.5	12.2	5.7	7.8	12.0	50.1	0.4	6.4	7.8	11.3	45.8
6/9	3.1	9.9	7.8	9.0	41.4	0.3	8.7	7.6	11.6	4.4	13.2	8.2	7.8	10.6	48.9	6.6	8.6	7.8	10.2	48.2	0.3	8.8	7.6	11.5	5.[illegible]

APPENDIX E: MEAN CATCHES OF FISH (OTHER THAN SALMON FRY)

Table E1

Mean Catch of Fish (Not Salmon Fry) by Location

Resurrection Bay, Alaska, 1986-1987

Species	Lowell		Greenhouse		North		Noname		Cliff		Houseboat	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1986												
Coho Salmon*	1.2	3.2	0.5	1.2	0.6	1.2	1.4	4.2	1.6	3.8	1.6	4.8
Dolly Varden	1.2	2.6	1.0	2.0	1.5	5.5	0.5	1.3	3.0	11.6	3.5	11.1
Sculpin**	1.3	1.5	3.8	6.1	0.3	0.6	0.3	0.6	1.7	2.6	0.2	0.5
Sand Lance	14.6	36.1	0.2	0.7	0.0	0.0	0.1	0.4	1.3	7.7	6.7	37.4
Starry Flounder	0.3	0.9	4.1	7.6	3.9	8.0	1.8	2.6	1.7	3.6	0.0	0.0
Smelt (larvae)	0.2	0.8	0.0	0.2	4.7	29.0	0.9	0.3	0.9	0.3	0.0	0.0
Herring	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.5	1.1	5.9
1987												
Coho Salmon	1.2	4.2	0.4	0.9	0.3	0.9	6.0	7.4	10.1	24.3	5.2	15.2

(Continued)

* Juveniles.
** Great and staghorn sculpins.

Table E1 (Concluded)

Species	Lowell		Greenhouse		North		Noname		Cliff		Houseboat	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1987 (Continued)												
Dolly Varden	8.2	18.4	0.4	0.9	1.0	2.5	0.7	1.4	2.3	5.7	2.5	9.4
Sculpin	0.2	0.4	2.1	5.5	0.6	1.9	3.5	9.9	5.9	14.8	1.3	2.3
Sand Lance	9.3	27.1	0.0	0.0	0.0	0.0	0.0	0.0	4.6	18.8	3.8	18.6
Starry Flounder	0.3	0.6	0.5	1.1	2.0	6.1	0.4	1.0	0.6	1.9	0.9	2.4
Smelt (larvae)	0.1	0.8	0.0	0.1	0.4	2.4	0.2	0.7	0.8	2.3	0.4	1.8
Herring	1.6	8.3	0.0	0.0	0.0	0.0	0.0	0.0	1.9	12.8	3.2	15.0

Table E2

Mean Catch of Fish (Not Salmon Fry) by Date, Resurrection Bay, Alaska, 1986-1987

Week	Coho Salmon*		Dolly Varden		Sculpin**		Sand Lance		Starry Flounder		Smelt (Larvae)		Herring	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1986														
4/3-4	0.0	0.0	0.0	0.0	0.4	0.7	0.0	0.0	0.5	1.3	0.0	0.0	0.0	0.0
4/9-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4/14-16	0.0	0.0	0.0	0.0	0.8	1.5	0.0	0.0	5.3	8.9	0.0	0.0	0.0	0.0
4/27-5/1	0.0	0.0	0.4	1.5	0.7	1.3	0.0	0.0	0.6	1.0	0.0	0.2	0.0	0.0
5/4-9	0.2	0.9	2.0	10.5	0.8	1.9	4.4	15.4	1.3	3.1	5.0	29.8	0.0	0.0
5/11-15	0.2	0.6	1.0	2.5	1.2	2.6	11.6	44.3	0.8	2.0	0.0	0.0	0.0	0.0
5/18-22	1.3	2.9	5.3	12.1	1.8	3.5	4.2	24.8	3.7	7.4	0.1	0.3	0.1	0.7
6/15-20	5.8	6.3	2.1	2.7	3.2	5.9	2.9	13.5	3.1	6.1	0.3	0.8	1.8	6.4
All	1.1	3.3	1.8	7.1	1.3	3.1	3.5	21.0	2.1	5.3	0.9	12.6	0.3	2.5
1987														
4/20-24	0.0	0.0	0.1	0.4	4.6	14.3	0.2	0.7	0.7	2.2	0.8	3.1	0.0	0.0
4/27-5/1	0.0	0.2	0.0	0.2	5.2	12.9	0.0	0.2	0.4	0.9	0.1	0.3	0.0	0.0
5/4-9	0.2	0.9	1.6	7.2	4.7	12.6	7.5	24.8	0.4	0.9	0.0	0.0	0.1	0.2
5/11-15	2.3	8.4	4.2	13.3	1.4	4.2	0.2	0.7	0.5	1.4	0.1	0.7	0.0	0.0
5/18-22	1.0	1.8	3.5	9.1	0.4	0.9	6.8	24.2	2.2	7.3	0.0	0.0	0.2	1.0
5/25-29	4.0	12.2	2.2	6.1	0.3	0.7	0.0	0.2	0.1	0.3	0.0	0.2	0.0	0.2
6/1-5	18.7	33.2	6.0	10.3	1.1	1.9	1.2	4.4	0.5	1.4	0.0	0.2	3.7	19.0
6/8-13	3.4	5.3	5.1	17.6	1.6	2.8	5.4	21.6	1.5	3.0	0.7	1.9	3.1	17.2
6/15-20	8.4	16.3	3.4	10.3	1.2	2.4	9.4	28.8	0.8	2.1	0.8	2.5	3.7	12.9
6/22-26	6.0	7.7	0.9	1.2	0.9	1.2	0.4	1.1	0.7	1.6	1.5	3.4	3.5	9.3
All	4.0	13.4	2.7	9.6	2.2	7.9	3.3	16.7	0.8	2.9	0.3	1.7	1.3	9.3

* Juveniles.
** Great and staghorn sculpins.